Understanding the Impact of Large-Scale Radio Astronomy Projects on Student Engagement with Physics in Ghana

Eugene Tetteh-Owusu Okwei

Submitted in accordance with the requirements for the degree of Doctor of Philosophy

University of Leeds

School of Physics and Astronomy

April 2023

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

Acknowledgements

I humbly wish to express my heartfelt thanks to the Almighty God for his protection, guidance, wisdom, knowledge, grace, mercy, power, and directions in all the accomplishments connected with this research, and also throughout my studies. I also thank the Almighty God for making this research possible. The genuineness of this research has been the result of the support given to me by a number of people, whose assistance need to be recognised.

I owe a depth of profound and sincere gratitude to my supervisors, Professor Samantha Pugh, Professor Melvin Hoare, and Dr. Robert Purdy who dedicated their precious time to guide me in this research. Their supervisory role in this research indicated their absolute obligation to this study. I am grateful for their constructive suggestions, patience, corrections, guidance, moral support, valuable assistance, and encouraging comments during the research.

I honestly acknowledge with great thanks the financial assistance from the Global Challenges Research Fund (GCRF), and Newton Fund/Development in Africa with Radio Astronomy (DARA) project to the development of this research. I am also very grateful to the School of Physics and Astronomy of the University of Leeds where the Newton Fund/DARA project is linked in the United Kingdom.

I am appreciative for the support, inspiration, and the significant discussions I have received from the Physics Education Research Group (PERG), and the Astrophysics Research Group at School of Physics and Astronomy of the University of Leeds during seminars. I thank you all for the stimulating discussions and companionship. Special thanks go to all current and past students of the Newton Fund/DARA project, Promoting Radio Astronomy in Ghana through School visits and Astronomy Clubs (PRAGSAC) and, to all my research participants.

Exceptional thanks also go to Mr. Olufemi Aluko a PhD Researcher at the International Business Department, Leeds University Business School of the University of Leeds for enthusiastically using his time and competency to proof-read some chapters of this research.

I owe deep and sincere thankfulness to all authors, whose books, journals, articles, reports, research works etc. I consulted during the writing of this thesis.

In conclusion, I am very grateful and highly indebted to the sacrifices of my beloved wife and children who provided me with much needed care and reassurance.

Abstract

In recent years there have been scientific developments nationally in Ghana in radio astronomy. One such project is the University of Leeds-led DARA project which trained teachers in radio astronomy. Many of these teachers returned to the classroom. The purpose of the study was to specifically understand the impact of large-scale radio astronomy projects on students' engagement with Physics in Ghana. In this study, mixed methods comparative study research design was used. The Sample for the study was DARA-trained teachers and their students and Non-DARA-trained teachers and their students. The sample size for the study was 902 students and 21 teachers. The sampling technique used for the study was purposive and opportunistic. Two main instruments were used in the study: questionnaire for the students and interview for the teachers. Quantitative and qualitative methods were used in analysing the data for the students and qualitative methods were used in analysing data for the teachers. The data collected was edited, encoded and analysed through the help of IBM Statistical Product and Services Solutions (SPSS) and the collected interview data were listened to, coded and categorized into themes of the research, based on the research questions. The findings of this study showed that there was significant difference between DARA and Non-DARA students. Non-DARA student's attitudes towards learning Physics, decisions to further study Physics at the Senior High Schools, Colleges of Education/ Universities, and perceptions on the relevance of studying Physics were more positive than DARA students.

The findings of the study revealed that DARA students knew of more Physics careers (career aspirations in Physics) than Non-DARA students and also they were more aware of the GRAO telescope/DARA project in Ghana than Non-DARA students. DARA students were more knowledgeable in Physics careers which was due to the impact of large-scale radio astronomy projects, however, it has not led to high student's engagement with Physics in Ghana as shown in the study. The findings also showed that DARA students demonstrated significant awareness of the GRAO telescope/DARA project in Ghana than Non-DARA students but this has not made more students to be engaged with Physics in Ghana. The study revealed that there was no difference between DARA teachers and Non-DARA teachers on attitudes towards the teaching of Physics, no difference in the perceptions on the relevance of studying Physics and lastly DARA teachers were more

knowledgeable in career aspirations/knowledge of career routes in Physics than Non-DARA teachers based on the extracts from the interview for the teachers.

Table of Contents

Contents

List of Tables

List of Figures

Chapter 1 : Introduction

Physics is an important branch of science and most fundamental of all other sciences. It is considered as one of the most important science subjects in education programs. It is normally taught as a mandatory subject in high schools, colleges, polytechnics and universities and its applications in programmes such as engineering, pharmacy, medicine, and dentistry (Koohawayrojanapakorn et al., 2018). Research studies have indicated low students' engagement in Physics and decline in the studying of Physics (Chief Examiner's Report for CoE, 2013-2015; Chief Examiner's Report [WAEC], 2006, 2012; Anamuah-Mensah, Mireku and Ghartey-Ampiah [TIMSS], 2009). Some physics concepts and theories are perceived to be difficult for students to understand e.g. the study of the universe. This perception might be a contributing factor to students' low performance and attitude towards Physics (Agina-Obu, 2005; Trumper, 2003). This informed the researcher to investigate the impact of large-scale radio astronomy projects on students engagement with Physics in Ghana. The study would be of much benefit to the Ministry of Education (MOE) and other educational stakeholders in the formulation of future Physics education policies aimed at enhancing students' engagement with Physics. This would help authorities come out with pragmatic measures to address students' engagement with Physics. This study would guide teachers in helping students to develop positive attitudes and engagement with Physics.

1.1 Background of the Study: Science in Africa

This study was situated in Ghana, Africa. It investigated the impact of large-scale radio astronomy projects on students' engagement with Physics in Ghana. Physics, as a discipline, deals with the nature of matter and energy, their interactions, and measurements. The study of Physics has had a continuous influence in communities worldwide. There are extensive applications of the concepts, skills and attitudes used in a variety of scientific and technological developments (Ghana Education Service, 2019); For example, improvement in renewable energy serves the world and it is hoped that there would be availability of this in Ghana to complement other energy sources to meet the energy needs of the nation. Ghana Education Service (2019) affirms that the principles and applications of physics is widely used in individual daily activities such as walking, lifting objects, seeing and taking photographs.

Globally, Africa has been known to be a continent of science and scientific discoveries. It continues to be attractive internationally in scientific developments. The continent has a vast rich field that can be used for scientific experiments and, expeditions. Ghana have advanced in science research which has led to scientific partnership across the globe (Sooryamoorthy, 2020). Examples include, the Urine Malaria Test (UMT), developed by a team of researchers from Ghana, which provides a simple and affordable method to diagnose malaria in resource-limited settings and also Kenya's Lake Turkana Wind Power Project which is one of the largest wind power installations in Africa, generating clean energy to meet a significant portion of the country's electricity needs.

According to Sooryamoorthy (2020), in many African countries, science is the major source of economic development and also science contributes to the development of nations and alludes to the fact that evidence of this has been provided in policy documents of these nations. Africa has made significant strides in space science and astronomy. For example, South Africa's MeerKAT radio telescope, part of the Square Kilometre Array (SKA) project, is one of the most powerful radio telescopes in the world, contributing to ground-breaking research in astrophysics. Ghana is currently making use of the science it produces for national development (Sooryamoorthy, 2020). For example, The location of Ghana 5◦ north of the Equator and its closeness to the undersea cables of Africa makes it possible to obtain greater bandwidth and fast internet connection (Asabere et al, 2015) which is very important in telecommunications. For educational purpose, the Ghana Radio Astronomy Observatory (GRAO) and Promoting Radio Astronomy in Ghana through School visits and Astronomy Clubs (PRAGSAC) members have developed online lessons in basic astronomy, python programming and careers in astronomy for high school students in the country (Aworka et al, 2021).

Africa, especially the West African countries is threatened with many challenges. The rise in population has caused continuous conflicts for the pursuit of resources and raw materials. There is increase in communicable diseases and poor agricultural yield which is due to climate change, and this has stimulated hunger and starvation. These obstacles have led to socioeconomic problems, unstable government and poverty which have prevented the development of Africa (Olusegun & Akinsanmi & Fasasi, 2019).

Most developed countries have enhanced their development through science and technology. Even though science commenced way back since the existence of mankind, the evolution of science has increasingly revolutionised the world to suit the desires of mankind, improve their wellbeing and make them comfortable (Olusegun & Akinsanmi & Fasasi, 2019).

1.2 Astronomy in Africa

One of the effective multidisciplinary instructive tool in the world is astronomy which embodies a unique mixture of science, technology and culture (see Figure 1.1). This has made astronomy a gateway to science disciplines such as physics, chemistry, biology and mathematics and play vital role in the driving of innovative developments in electronics, optics and information technology in the 21st century. The golden age of astronomy is now based on ground-based and space observatories (Miley, Ödman & Russo, 2019).

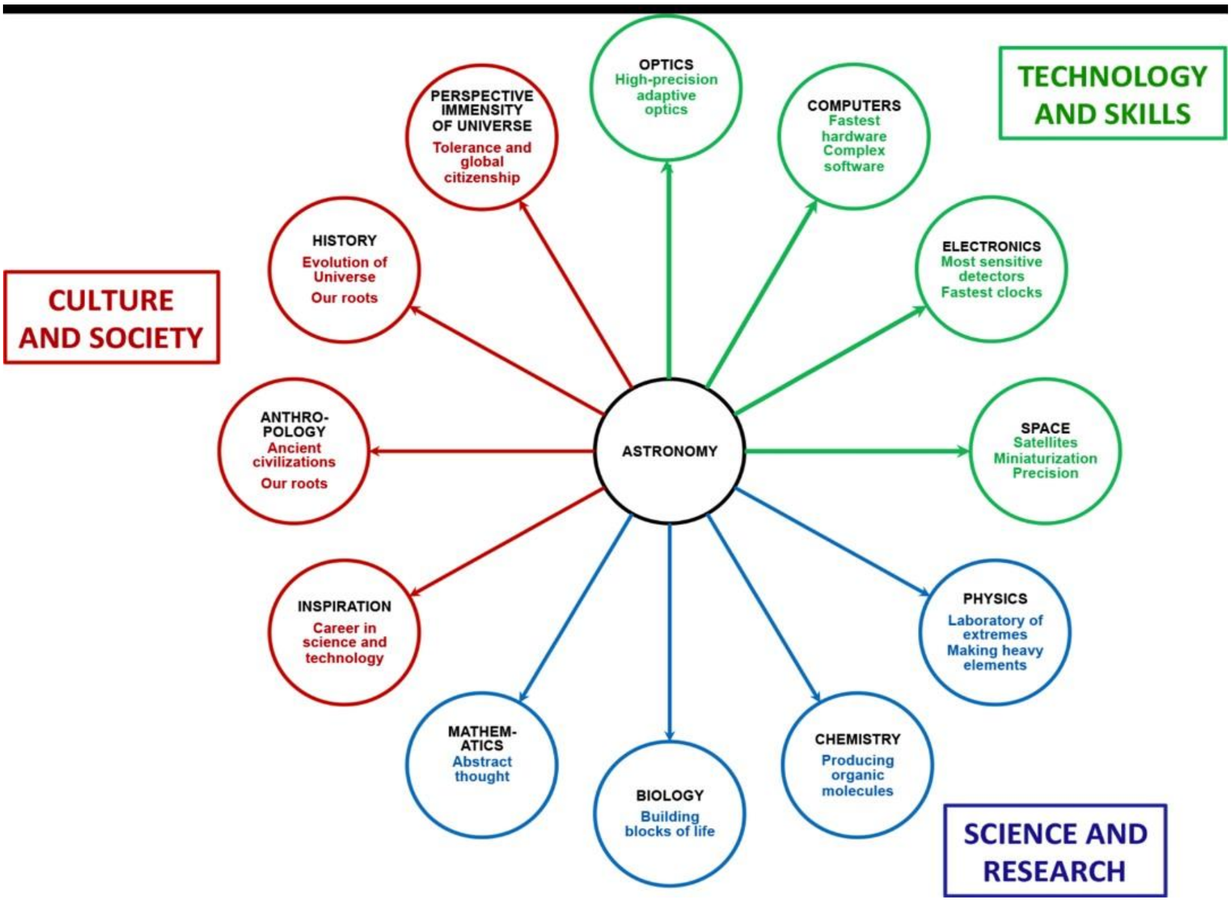


Figure 1.1:The wide applicability of astronomy and space sciences as an educational tool and a gateway to science, technology and culture (International Astronomical Union Strategic Plan: 2011, Miley 2012)

Historically, there has been advancement of astronomy and space science in the African continent. The developments within the continent in science and technology has allowed Africa to achieve future goals such as the United Nations (UN) Sustainable Development Goals (SDGs). Currently, there are new scientific partnerships within the continent which is of great essence to the growth of Africa and for all to make the world a better place (Pović *et al,* 2018).

In recent times, the observatories in South Africa for example the Southern African Astronomical Observatory (SAAO) and Hartebeesthoek Radio Astronomy Observatory (HartRAO), and other observatories were the only astronomy references in Africa. Many other African countries like Ghana and Kenya commenced research programmes and studies in astronomy and space science (A&SS), which started with institutional growth, human capacity development (HCD), scientific studies and networking. By improving some of the major socioeconomic and environmental challenges is facing African countries, the African Union (AU) took major steps to help promote the development of A&SS and achieve United Nations Sustainable Development Goals (Pović *et al,* 2018).

The International Astronomical Union's Office of Astronomy for Development has been funding various astronomy projects across the globe to help promote astronomy. Africa has tapped and used this initiative helped the continent to grow academically, technologically, and for socioeconomic development (McBride *et al,* 2018). The objective of the International Astronomical Union's Office of Astronomy for Development (IAU OAD) is to use the tools, skills and research methodologies in astronomy to contribute to socioeconomic development, which is in agreement with the United Nations Sustainable Development Goals (UN SDGs). The IAU aim is not only to develop astronomy as a discipline in Africa, but there should be development in the areas of education, technology and public engagement initiatives that can empower developmental goals within the continent (McBride *et al,* 2018).

In section 1.2, it clearly shows that African countries (South Africa, Ghana etc.) have been actively involved in advancing astronomy and space science through collaborations with other international organizations (large-scale radio astronomy projects for example the DARA project, SKA project etc.). Hence, the reason for me to investigate the impact of large-scale radio astronomy projects (DARA project) on students engagement with Physics in Ghana.

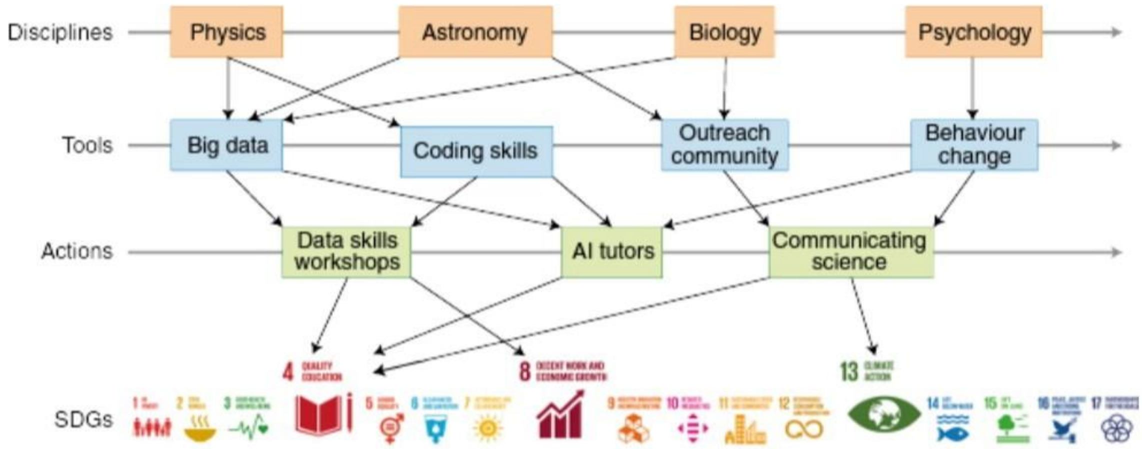


Figure 1.2: An illustration of science for development, where astronomy is only a part of the broader contribution of science towards the SDGs. Credit: SDG icons courtesy of UN/SDG and (McBride *et al,* 2018).

Astronomy is very important in the development of Ghana in the following ways:

- The Ghana Radio Astronomy Observatory (GRAO) has essential science instruments such as Meteorological unit (MET-4), Global Navigational Satellite System (GNSS) receivers, seismometer, gravimeters, and magnetometers (Asabere et al, 2015).
- In Ghana, astronomy is very vital in the applications of ecology (Aworka et al, 2021).
- Recent development of Ghana has been due to innovative research in the field of astronomy. The Ghana Space Science and Technology Institute (GSSTI) has been involved in various research studies/activities that are in line with addressing the UN SDGs (Aworka et al, 2021).
- The GRAO is also still in the progress of building on human capital development and improving the socio-economic status of the immediate community and the nation as a whole (Aworka et al, 2021).

- In addition, the GRAO serves as a training centre for students. Students from the other African VLBI (Very Long Baseline Interferometry) Network (AVN) partner countries have had trainings at the observatory (Aworka et al, 2021).
- The GRAO has had impact on the socio-economic development of the country (Aworka et al, 2021).
- Finally, the introduction of a hydrogen maser-a precision reference clock to the observatory has essentially been advantageous to the nation and also serves as a standard reference time for the whole nation (Aworka et al, 2021).

1.3 Development in Africa with Radio Astronomy (DARA) Project

The training of Africans in the high tech skills associated with radio astronomy was funded by the UK Government's Newton Fund and Global Challenges Research Fund. This was done as the African continent is gearing to host the world's biggest radio telescope, Square Kilometre Array (SKA), (Okwei et al, 2022). The aims of the project were:

- to help drive economic development in Africa (Hoare, 2018).
- to develop high tech skills using radio astronomy in a number of African countries including Ghana (Hoare, 2018).
- to inspire and train a new and diverse generation of young people to engage with Science, Technology, Engineering and Mathematics (STEM) skills (Development in Africa with Radio Astronomy, 2019; Hoare, 2018)
- to provide a pool of talented young people who have been inspired by astronomy to play a leading role in the emergence of new economies (Development in Africa with Radio Astronomy, 2019; Hoare, 2018).

The DARA project was a partnership between UK-South Africa Newton Fund human capital development which was led by the University of Leeds. Radio astronomy involves all of the STEM skills that underpin the emergence of a strong developed economy (Development in Africa with Radio Astronomy, 2019; Hoare, 2018). The project delivered training in radio astronomy to the residents of eight African partner countries namely: Ghana, Kenya, Zambia, Namibia, Botswana, Madagascar, Mozambique, and Mauritius. The training was provided by a joint collaboration between UK and South African team that included staff from the some selected universities in the UK namely

University of Leeds, Manchester, Oxford, Hertfordshire, Central Lancashire and Bristol. In South Africa, the lead partner was the South African Radio Astronomy Observatory (SARAO), with contributions from several South African universities as well (Hoare, 2018). The training was on basic radio astronomy and was delivered in modules to ten trainees per year per country. The basic training included radio astronomy, leading to applications for Masters and PhD degrees overseas, especially in the UK (see table 1.1). Others won bursaries to study in South Africa. DARA PhD students were funded to return home each year and build links with key institutions so that they had jobs to return to counter any potential brain drain (Development in Africa with Radio Astronomy, 2019; Hoare, 2018). In 2015, a further 10 MSc degree programmes were awarded by the SARAO bursary programme.

Table 1.1: DARA Applications from 2015-2019

Year of award	Degree	Applications	Total number of Applications	Number of award	Number graduated
2015 round UK	Master of Sciences (MSc)	19	29	3	3
	Doctor of Philosophy (PhD)	10		3	3
2017 round UK	MSc	43	59	3	2
	PhD	16		4	4
2019 round UK	MSc	51	51	6	6
2019 round Mauritius	Master of Philosophy (MPhil.)	46	46	6	unknown

Business experts from GES, and the South African industrial partner, the South African National Space Agency, were able to demonstrate to the trainees how the collaborations between radio astronomy, space science and satellite communications can work to deliver employments and production of wealth during DARA’s annual network meeting (Development in Africa with Radio Astronomy, 2019; Hoare, 2018).

During the project, past DARA Masters and PhD students gathered at Goonhilly to see first-hand how radio astronomy and the commercial satellite communications business can work together. Many of the institutions developing around the AVN dishes had dual roles in both radio astronomy and space science applications (Development in Africa with Radio Astronomy, 2019; Hoare, 2018).

Further funding was received from the UK's Global Challenges Research Fund, DARA was able to fund small proposals drawn up by the African trainees to use radio astronomy for development and outreach. The outreach projects aimed to inspire more school children in each of the African countries to consider studying STEM subjects to a higher level; hence, equip more people with the kind of skills needed in the current economy (Development in Africa with Radio Astronomy, 2019; Hoare, 2018; Okwei et al 2022).

1.4 The African VLBI Network (AVN)

The African VLBI Network (AVN) is

> *''a network of VLBI-capable radio telescopes on the African continent that will strengthen the science which the international VLBI community can do.''*
> *(Gaylard et al., 2011).*

One of the aims of the AVN is to develop the skills, regulations and institutional capacity needed in SKA partner countries to optimise African involvement in the SKA and enable involvement in SKA pathfinder development in science and technology. Secondly, it will utilise transferable skills and knowledge in African partner countries to build, maintain, operate and use radio telescopes. In addition, it will bring new science opportunities to Africa on a relatively short time scale and develop radio astronomy science communities in the SKA partner countries. In one of the annual SKA African Partner Countries Ministerial Meeting held in Pretoria, it provided evidence of political and strategic leadership to African SKA partner countries on the AVN, SKA and other relevant astronomy programme and initiatives. The SKA AVN partners of South Africa are: Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia, and Zambia (Gaylard et al., 2011).

1.5 The SKA Project

The SKA project is

> ''an international effort to build the world's largest radio telescope, with a square kilometre (one million square metres) of collecting area.''

The SKA telescope will be co-located in Africa and Australia. There will be extraordinary scope in observations, exceeding the image resolution quality of the Hubble Space Telescope by a factor of 50 times, and also have the ability to image large areas of sky in parallel. With a range of other huge telescopes in the optical and infrared being built and launched into space over the coming decades, the SKA is going to impeccably augment, supplement and be a leader in scientific discovery (Berry, 2021). The SKA Organization has its headquarters at Jodrell Bank Observatory located in Manchester, UK. The aim of the project is to formalise relationships between the international partners and to centralise the leadership of the project. The SKA Organisation has eleven countries as its members currently. These include Australia, Canada, China, Germany, India (associate member), Italy, New Zealand, South Africa, Sweden, the Netherlands and the United Kingdom (Berry, 2021).

1.6 The SKA in Africa

South Africa is the leading country in Africa with demonstrable excellent science and engineering skills which was used to design and build the MeerKAT telescope – as a pathfinder to the SKA. KAT-7 comprises of the first seven dishes, which has been completed and produced its first images. MeerKAT is attracting great interest all over the world – more than 500 global astronomers with 58 from Africa submitted proposals to do science with MeerKAT once it was completed (Gibbon et al, 2014).

According to Gibbon et al. (2014), the technology being developed for MeerKAT is cutting-edge and the project is creating a large group of young scientists and engineers with world-class expertise in the technologies which will be crucial in the next 10 – 20 years, such as very fast computing, very fast data transport, large networks of sensors, software radios and imaging algorithms (Gibbon et al, 2014).

McBride et al. (2018) allude to the fact that since 2005, the African SKA Human Capital Development Programme has awarded close to 1000 grants in 2017 for studies in astronomy and engineering from undergraduate to post-doctoral level, while also investing in training programme for technicians. Astronomy courses are being taught as a result of the SKA Africa project in Kenya, Mozambique, Madagascar and Mauritius (which has had a radio telescope for many years) and are soon to start in other countries, with Ghana recently starting.

1.7 Developments and Astronomy Outreach Project in Ghana

The project, "Promoting Radio Astronomy in Ghana through School Visits and Astronomy Clubs" (PRAGSAC) introduced students to practical astronomy topics to build their interest in science for an informed academic and career choices. By working through school visits and formation of school clubs, students were exposed to basic applied Astronomy for them to appreciate the importance and benefits of the Ghana Radio Astronomy Observatory (GRAO) located in Kuntunse. The target audience was Junior High School (JHS) students, with the aim of promoting a greater interest in science so that more students would choose Science at Senior High School (SHS). The initial plan was to work with a cluster of 4 schools close to the location of the GRAO. Teacher training was an important part of the project, to ensure long sustainability of the clubs. Teachers were also made aware of programmes such as WAISSYA, scholarship opportunities (Masters/PhD) and the Basic Radio Astronomy Training Programme funded by DARA (Okwei et al, 2022).

1.8 Operational Definition of Terms

For better understanding of this research work, the following terms referring to education in Ghana were defined in order to reduce ambiguities.

Junior High School (JHS): lasts for three years (age 12-15). JHS is compulsory for all children. The Junior High School ends on the Basic Education Certificate (BECE), which covers the following subjects: English Language, Ghanaian Language and Culture, Social Studies, Integrated Science (which includes Physics, Chemistry and Biology) Mathematics, Basic Design and Technology, Information and Communication Technology, French (optional), Religious and Moral Education.

Senior High School (SHS): Refers to level of education in Ghana after completing BECE. It covers three years (age 16-19). SHS is not compulsory. The SHS curriculum is composed of core subjects, completed by elective subjects (chosen by the students). The core subjects are English language, mathematics, integrated science (including Physics, Chemistry and Biology, ICT and environmental studies) and social studies (economics, geography, history and government). The students then choose 3 or 4 elective subjects from 5 available programmes: agriculture programme, general programme (divided in 2 options: General Arts or General Science including Physics), business programme, vocational programme and technical programme. The SHS ends with a final exam called the West African Senior School Certificate Examination (WASSCE). Physics is taught as a one of the Science subjects in the Science programme.

Colleges of Education: This refers to the teacher training colleges of formal education in the Ghana school system. It covers a period of four years (age 19 years and above). Tertiary institutions established to train professional teachers to teach at the basic schools in Ghana after completion of SHS.

Universities: Tertiary institutions in Ghana that offer various academic programmes from bachelors to doctor of philosophy degrees after completion of SHS/College. It covers various periods of duration (age 19 years and above).

DARA Teachers: Teachers in various educational institutions in Ghana that participated in the DARA basic training programme.

DARA Students: Students of DARA teachers in various educational institutions in Ghana that participated in the DARA basic training programme.

Non-DARA Teachers: Teachers in various educational institutions in Ghana that have not participated in the DARA basic training programme.

Non-DARA Students: Students of Non-DARA teachers in various educational institutions in Ghana that have not participated in the DARA basic training programme.

1.9 Education in Ghana

Ghana's educational system has undergone a lot of transformational processes. In 1987, the structure and content of education in the country resulted in a substantial decline in the number of years of secondary education offered from 17 to 12 years (Aheto-Tsegah, 2011). The current education in Ghana runs through elementary school education up to tertiary education. The elementary education system covers a period of nine (9) years consisting of six (6) year Primary school education and three (3) year Junior

High School education. This is followed by four (4) years of Senior High School education or Technical and Vocational Education. From this level one may then enter a tertiary educational institution to pursue further studies from three (3) or four (4) years as may be indicated in the various tertiary institutions. Tertiary education in Ghana consists of universities and colleges, as well as polytechnics, institutes and post-secondary institutions offering courses leading to the award of diplomas and degrees. The former structure of education in Ghana before the rolled-out of the Standards-Based Curriculum for Kindergarten and Primary schools and the Common Core Programme for the JHS in September 2019 and January 2021 respectively is as follows (Aheto-Tsegah, 2011; (Adu-Agyem & Osei-Poku, 2012):

• Basic/elementary education level: eleven years – comprising early childhood education (two years), primary (six years) and junior high school (three years).

• Second cycle education: three years – consisting of senior high school grammar and technical education, as well as other post basic skills-development programme, including the National Apprenticeship Programme.

• Tertiary level education: comprising diploma and degree programmes at colleges of education and polytechnics, as well as undergraduate programmes spanning a minimum duration of three years (for diploma programmes) and four years (for undergraduate degree courses).

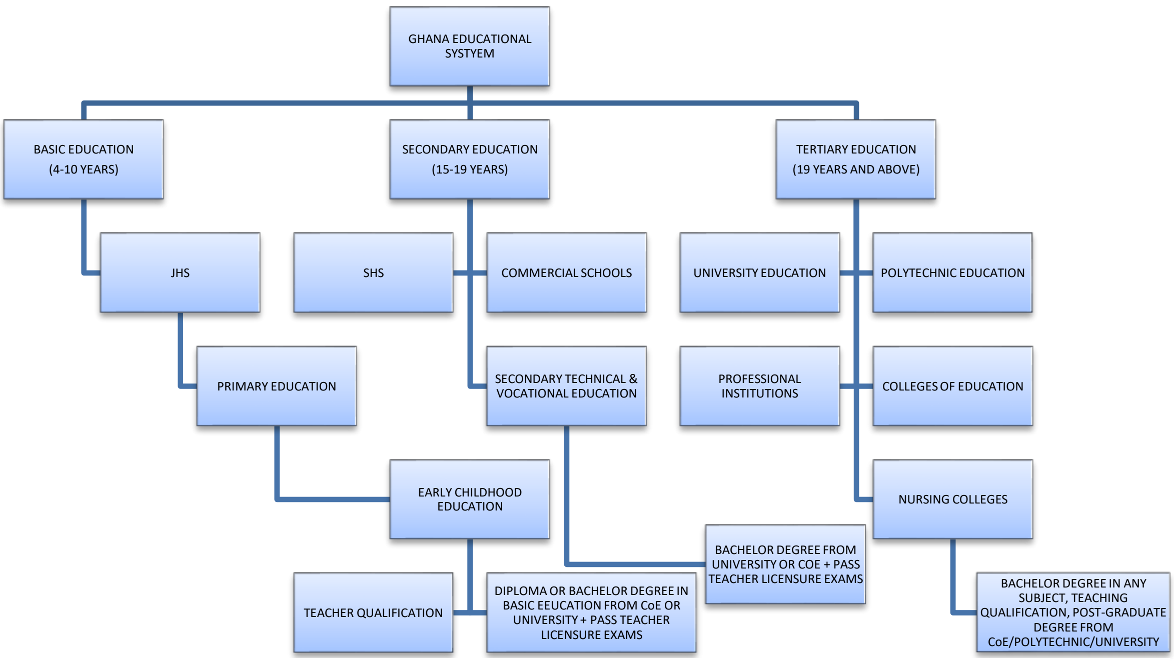


Figure 1.3: Visual Representation of the Educational System in Ghana

In Ghana, the sciences taught in SHS are biology, chemistry, physics, and integrated science. The SHS Physics syllabus builds upon the foundations laid in the Junior High School (JHS) integrated science at the basic level and the integrated science at the SHS (Curriculum Research and Development Division (CRDD, 2008). The topics in the syllabus have been selected to enable the students acquire the relevant knowledge, skills and attitudes needed for tertiary level education, apprenticeship, and for life (CRDD, 2008).

Physics has been generally taught as a compulsory subject in high schools in Ghana in order to construct essential knowledge, with an expectation for further application in university programmes such as engineering, pharmacy, medicine, and dentistry (Koohawayrojanapakorn, et al., 2018). The teaching syllabus for Physics (Senior High School 1-3) in Ghana (Ghana Education Service, 2019) also defines Physics in a similar way as defined by Koohawayrojanapakorn et al. (2018) and also compared with the United Kingdom (UK) General Certificate of Secondary Education (GCSE) Physics syllabus (Superprof Magazine, 2018) which has some elements same as the teaching syllabus for Physics (Senior High School years 1-3) in Ghana (Ghana Education Service, 2019). The Physics syllabus embodies a wide range of activities such as projects, experiments, demonstrations and scientific enquiry skills (CRDD, 2008). Physics has been recognised as an important academic subject to every society.

The reason for this is due to the fundamental role it plays in modern scientific and technological developments. Despite this, students' performance in the subject at the national and internal examinations has been relatively low (Chief Examiner [WAEC], 2012; Anamuah-Mensah, et al 2009; Buabeng, et al, 2014). A study conducted by Buabeng and Ntow (2010) shown a wide range of reasons which accounted for the negative students' response to Physics in Ghana. Buabeng and Ntow (2010) found among the students noticeable factors that were teacher factor, poor performance, and perceived difficulty nature of Physics. Majority of the students recounted that there is a reduced interest in the subject at the Senior High School (SHS) level because the subject was poorly taught to them. Remarkably, Physics teachers who participated in the study admitted that poor teaching was one of the many reasons that accounted for the decline interest level among the students (Buabeng & Ntow, 2010).

1.10 Teaching of Physics

Physics is an important subject for economic, scientific and technological growth (American Physics Society, 2008; Zhaoyao, 2002). According to Buabeng et al. (2014) empirical studies from the field of Physics Education Research (PER) have outlined recommendations about Physics syllabus which are generally accepted and believed to broaden the knowledge and increase the horizon of understanding of Physics by students. This was highlighted due to the fact that, learning efficiency and effectiveness take place during explanation, experimentation and discussion (Buabeng et al., 2014). During Physics lessons, there should be interaction between the Physics teacher and the students. Hence, it is believed that if genuine and helpful interaction exists between the teacher and students, the students will be able to inform teachers what they find difficult in Physics thereby eliminating the difficulties the students face (Adeyemo, 2010). Adeyemo (2010) identified that these features are necessary because it is believed that if they are duly and critically followed and applied, teachers will be able to make Physics easier to understand by students.

The desire in choosing to pursue Physics at higher levels (beyond secondary education) is influenced by the achievement rate and the foundation a student receives in Physics at the high school (Buabeng et al., 2014). The syllabus used for this research was based on the old Ghana Education Service (GES) syllabus (2007-2012). In response to the 2018 educational reforms proposed by the Educational Sector Plan 2018-2030, the National Council for Curriculum and Assessment (NaCCA) developed and rolled-out the Standards-Based Curriculum for Kindergarten and Primary schools and the Common Core Programme for the JHS in September 2019 and January 2021, respectively.

1.11 Organization of the JHS Syllabus in Ghana

The syllabus covers three years of Junior High School education. Each year's work is organized under the five themes or sections. The themes are: Diversity of matter (living and non-living things), Cycles, Systems, Energy and Interactions of matter (living and non-living things). Under each theme or section are a set of units or topics. The knowledge, understandings as well as the activities and range of process skills presented in each theme have been extended at the different class levels. The focus of each theme is provided below.

Table 1.2: Structure of JHS Integrated Science

Sections	JHS1	JHS2	JHS3
Diversity of Matter	Unit 1: Introduction to Integrated Science Unit 2: Matter Unit 3: Measurement Unit 4: Nature of Soil Unit 5: Hazards	Unit 1: Elements, Compounds and Mixtures Unit 2: Metals and Non Metals Unit 3: Chemical Compounds Unit 4: Water	Unit 1: Acids, Bases and Salts Unit 2: Soil and Water Conservation
Cycles	Unit 1: Life Cycle of Flowering Plants Unit 2: Vegetable Crop Production Unit 3: Fish Culture	Unit 1: Carbon Cycle Unit 2: Climate	Unit 1: Life Cycle of the Mosquito Unit 2: Animal Production
Systems	Unit 1: Respiratory System of Humans Unit 2: Farming Systems	Unit 1: Reproduction and Growth in Humans Unit 2: Heredity Unit 3: Diffusion and Osmosis Unit 4: Circulatory System in Humans	*Unit 1: The Solar System* Unit 2: Dentition in Humans Unit 3: Digestion in Animals
Energy	Unit 1: Sources and Forms of Energy Unit 2: Conversion of Energy	Unit 1: Photosynthesis Unit 2: Food and Nutrition Unit 3: Electrical Energy	Unit 1: Heat Energy Unit 2: Basic Electronics

	Unit 3: Basic Electronics Unit 4: Light Energy	Unit 4: Basic Electronics	
Interactions of Matter	Unit 1: Ecosystems	Unit 1: Physical and Chemical Changes Unit 2: Infections and Diseases Unit 3: Pests and Parasites Unit 4: Force and Pressure Unit 5: Machines	Unit 1: Magnetism Unit 2: Technology and Development Unit 3: Machinery Unit 4: Entrepreneurship

From Table 1.2 (CRDD, 2008), in the JHS 3 syllabus column, there is an Astronomy topic (the solar system) which has been included in the curriculum. Hence, Astronomy is very relevant in the curriculum of the SHS Physics syllabus and also the JHS Integrated Science syllabus in Ghana.

1.12 Organization of the SHS Physics Syllabus in Ghana

The syllabus has been structured to cover three years of SHS programme. Each year's work consists of a number of sections with each section comprising a number of units. There are seven main sections. These are:

Section one: Introductory Physics and properties of matter

In this section, the importance of Physics in everyday life is discussed. Certain topics in basic mathematics to enhance the study of Physics are discussed. Some phenomena associated with properties of matter are to be explained using the kinetic theory.

Section two: Mechanics

In this section, the types of motion are discussed. These include rectilinear motion, circular motion and oscillatory motion. The effects of force on motion and on matter are to be discussed in this section. The nature of energy, the conversion and conservation of energy are to be treated with special emphasis on the ways of harnessing renewable energy resources.

Section three: Thermal Physics

In this section, heat and temperature are discussed. The study of temperature, its measurement and the effect of temperature changes are to be discussed. The quantity of heat given out or absorbed and the physical changes due to heat transfer are discussed. Natural modes of heat transfer, are to be discussed with special emphasis on black body radiation.

Section four: Waves

The general characteristics of wave motion including that of light and sound waves are to be discussed in this section. The utilization of electromagnetic waves, especially that of microwaves in communication and industry and application of sound waves are given special emphasis. Fibre optics and lasers which have wide applications in industry and medicine are new topics introduced in the elective Physics syllabus with special emphasis on how they can be utilized.

Section five: Electricity and magnetism

Special emphasis is given to the study of magnets since magnets play a major role in instrumentation and machinery. The utilization of electromagnetic fields in the generation and storage of electricity and in electromagnetic relay are given special emphasis in this syllabus. The phenomenon of thermoelectric effect and its application is also to be treated in this section.

Section six: Atomic and nuclear Physics

The characteristics of the atom and that of the nucleus are discussed in this section. The concept of photoelectric effect and its applications, the x-rays and the peaceful uses of nuclear energy are to be discussed in this section.

Section seven: Electronics

From primary one to Senior High School, electronics has been introduced into Natural Science and Integrated Science with hands-on activities. In this section, another dimension of electronics is to be treated to include the characteristics and applications of semi-conductor diode and transistors electronic switching and integrated circuit (I.C) is provided in the last section (CRDD, 2008). At the end of the school year, students write a national examination, the West African Senior Secondary Certificate Examination (WASSCE) formally called Senior Secondary School Certificate Examination (SSSCE). The performance of students in the examination is used for selection into tertiary institutions.

Topics in Astronomy such as telescopes etc. are embedded in the SHS Physics curriculum in Ghana but it is not treated as a subject on its own. Astronomy is therefore relevant in the Physics curriculum in Ghana (CRDD, 2008).

Table 1.3: Structure of the SHS Physics Syllabus

Year One	Year Two	Year Three
Section 1 : Introductory Physics and properties of matter Unit 1: Introduction to Physics and physical quantities Unit 2: Physical quantities Section 2 : Mechanics Unit 1: Kinematics Unit 2: Dynamics Unit 3: Forces Unit 4: Pressure Section 3: Thermal Physics Unit 1: Temperature and its measurement Section 4 : Waves	Section 1: Introductory Physics and properties of matter) Unit 1: Concept of matter Section 2: Mechanics Unit 1: Energy Unit 2: Circular motion and Gravitation Unit 3: Oscillatory motion Section 3: Thermal Physics Unit 1 : Thermal properties of matter and Calorimetry Section 4: Waves *Unit 1: Thin lenses and optical instruments* Unit 2: Wave motion	Section 1: Introductory Physics and properties of matter Unit 1: Some properties of matter Section 2: Mechanics Unit 1 : Deformation of solids Section 3: Thermal Physics Unit 1: Heat transfer Section 4: Waves Unit 1: Introduction to Laser Section 5: Electricity and Magnetism

Unit 1: Reflection of light from plane and curved mirrors Unit 2: Refraction of light Unit 3: Basic Fibre optics Section 5: Electricity and Magnetism Unit 1: Electrostatics Unit 2: Capacitors Section 6: Atomic and Nuclear Physics Unit 1: Models of the atom and atomic structure Section 7: Electronics Unit 1: Semiconductor P-N Junction diode	Unit 3: Sound Section 5: Electricity and Magnetism Unit 1: Direct current circuit analysis Unit 2: Magnets Unit 3: Electromagnetism Section 6 : Atomic and Nuclear Physics Unit 1: Photoelectric effect and wave particle duality Unit 2: Thermionic emission, cathode rays and xrays Section 7: Electronics Unit 1: Bipolar Junction Transistor (BJT)	Unit 1: Electromagnetic Induction Unit 2: Alternating Current (A.C.) theory Section 6: Atomic and Nuclear Physics Unit 1: The nucleus and nuclear energy Section 7: Electronics Unit 1: Digital electronics and Integrated Circuits(I.C)

1.13 Positionality

Over the past 10 years, I have been teaching Physics at the various levels of education in Ghana. Students that I have tutored and students that I have not tutored often find Physics to be difficult and abstract. Many students that I have taught find it difficult to study Physics at the secondary and tertiary level of education in Ghana, therefore there is a decline rate of students studying Physics at these levels. I was one of the postgraduate trainees who was selected for the DARA trainee programme in radio astronomy, a DARA Teacher. One of the reasons why I am conducting this study is that I am a DARA Teacher and wants to investigate how the DARA programme has had impact on the DARA teachers for their students to be engaged in Physics.

I was one of the students during my secondary education had some difficulty with the learning of Physics but was able to succeed in Physics and became more interested in Physics when I was studying at the university. I was able to overcome this difficulty by working assiduously towards achieving my goal in becoming a Physics Tutor. This has made me to be interested in what really takes students during the period of teaching and learning for them to enjoy Physics so that they can engage meaningfully in it. This stimulated me to undertake this study on Understanding the Impact of Large-Scale Radio Astronomy Projects on Students Engagement with Physics in Ghana. I believe that effective teaching and learning takes place in the classroom when there is a good environment with specific references to the students' interest in class. In view of this, students need to be motivated and engaged with Physics through various activities so that the teacher can create conducive environment in class.

It is my belief that student's engagement with Physics requires teaching and learning processes which support in depth study, pedagogical methods, devotion to duty, additional time, and determination to study Physics. In this way, the students become more engaged in Physics. This produces an essential type of engagement and escalation of students in studying Physics as a subject. A body of research suggests that, in Ghana, Physics is seen as a difficult subject and only few students are able to understand it very well and to further decide in choosing to study it from one level to the other. It was of this view that am conducting this research to help students to be more engaged in the subject. Given the teaching and learning of Physics and the decline rate at which students engage in it, it is very significant for me to conduct this research/study. The aim is to understand the impact of large-scale radio astronomy projects and how it can help students to engage in Physics in Ghana.

I'm of the view that majority of students should be engaged in Physics in Ghana. Students' engagement with Physics in Ghana is of much importance to the socioeconomic development of Ghana, parents, and all stakeholders of education in Ghana. There are several educational research studies in this area of my research; notwithstanding, I strongly believe that my position and views, own experience and opinions would have impact and guide the objectives of this study and the research questions. Nevertheless, my position on this study will not have any impact on the data collected.

1.14 Aim of the Study

The purpose of the study was to specifically understand the impact of large-scale radio astronomy projects on students' engagement with Physics in Ghana. Also, teachers who participated in the DARA programme should be able to inspire and encourage their students to be engaged in Physics. Hence, the hypothesis of the study is that the DARA programme should impact students to be engaged with Physics in Ghana. Therefore, DARA students should experience higher engagement with Physics than Non-DARA students.

1.15 Objectives and Research Questions

The following objectives and research questions were formulated to guide the study:

To find out the differences between DARA students and Non-DARA students in their:

1. attitudes towards learning Physics.
2. decisions to further study Physics at the SHS and Universities.
3. perceptions on the relevance of studying Physics.
4. career aspirations in Physics.
5. awareness of Radio Astronomy.

To determine the differences between DARA teachers and Non-DARA teachers in their:

6. attitudes towards teaching Physics.
7. perceptions on the relevance of studying Physics.
8. Knowledge of career routes in Physics.

1.16 Research Hypothesis

The following research hypothesis was posed to guide the study:

1. Null Hypothesis (H_o): DARA students experience more positive responses to the research questions than Non-DARA students.

1.17 Ethical Approval

Ethical approval was obtained from the Faculty of Engineering and Physical Sciences (FEPS) research ethics committee. Ethics reference: MEEC 19-004. The University of Leeds Research Ethics Committee Application Form was completed and submitted by email to researchethics@leeds.ac.uk (the Faculty of Engineering and Physical Sciences (FEPS) research ethics committee). The process of the application was discussed with my supervisor and all questions on the form was answered. The application form was signed electronically by the researcher and supervisor. Risk assessment was required for the study, which was completed and submitted to the School of Physics & Astronomy Health and Safety Officer, which was signed by the School of Physics & Astronomy Health and Safety Officer prior to field work and data collection. The researcher travelled to Ghana for the fieldwork and collect data.

Included in the submission of the application was all supporting materials such as the researcher's participant information sheet for the students and teachers, participants consent form, questionnaire for the students, interview questions for the teachers, Head teacher invite letter and teacher invite letter. The study was not a longitudinal study but a comparative study hence there was no need to keep or inform the researchers if participants contact details change over the next 10 years. Participation for teachers and students was optional and voluntary. Invite letters were sent to the teachers and Head of schools by email in advance prior to the fieldwork and data collection.

1.18 Significance of the Study

The research seeks to bring to the doorsteps of policy makers, curriculum developers, implementing bodies and other stakeholders the lived reality in schools so that they can have a fair assessment and judgement of the impact of the DARA programme on students' attitudes towards learning Physics, decisions to further study Physics at the Senior High Schools/Universities/Colleges of Education, perceptions on the relevance of studying Physics, career aspirations in Physics, and awareness of Radio Astronomy.

It will also help to understand whether students are inspired to further study Physics at the Senior High Schools/Universities/Colleges of Education and also have knowledge of various careers in Physics in Ghana. Lastly, this research will serve as a document or a reference material for those who will like to do further research on the impact of the DARA project in Ghana or any African country associated with the DARA project or similar interventions.

1.19 Limitations of the Study

For the purpose of external validity, such a study should have been conducted in a good number of JHS/SHS/Universities/Colleges in all the ten regions in the country. Unfortunately, due to time and financial constraints, the study was restricted to only some JHS/SHS/ Universities/Colleges students and teachers in Ghana. Other inconveniencies such as school timetable, teachers' presence and honest responses from respondents will have an impact on the study. Also, due to the COVID-19 pandemic, which led to the closure of JHS, SHS, Universities and Colleges of Education in Ghana, the data collection period was curtailed. Fieldwork was cut short due to the lockdown. Furthermore, it was not possible to revisit any of the schools. The study was limited to DARA teachers and their students and Non-DARA teachers and their students in a limited number of regions in Ghana, it was difficult to widen the scope of the study to cover a lot of Non-DARA teachers and their students in other regions in Ghana. The results could therefore not be generalized to all JHS, SHS, Universities and Colleges of Education in Ghana.

1.20 Delimitations of the Study

In all, about 1000 questionnaires were administered in the schools. The sample was selected from the JHS, SHS, Universities and Colleges of Education in Ghana of the DARA and Non-DARA teachers and their own students only. However, due to the limitations already outlined, the study was focused on only DARA teachers and their students in the Greater Accra region and Non-DARA teachers and their students in the Central region only.

1.21 Organisation of the Study

This research report is presented in seven chapters. Chapter one titled introduction comprises of background and general concepts of the study.

Chapter two, titled Literature Review, deals with what has already been written about the topic in terms of theories and empirical evidence. The review is geared towards justifying the defined objectives of the research and establishing the theoretical framework for the research work. It also identifies the gaps in the literature in which the study attempts to fulfil. In addition, it covers the summary of major findings of the literature review.

Chapter three, titled Research Methodology, provides information on the research participants, the research design including sampling techniques, procedures (including evidence of ethical considerations), and instruments used in both data collection, and analysis.

Chapter four, titled Results and Findings on Students Questionnaire, deals with the outputs of the quantitative and qualitative research presented, analysed and explained.

Chapter five, titled Results and Findings on Teachers Interview, deals with the outputs of the qualitative research presented, analysed and explained.

Chapter six, titled Discussion of Findings, considers the significant and novel findings. It also highlights the major findings of the research and the inferences made from them in view of findings from related previous studies.

Chapter seven, titled Conclusions, Limitations and Suggestions for Future Work, deals with the conclusions, recommendations, limitations and suggestions for further study or research.

Chapter 2 : Literature Review

2.1 Overview

The chapter provides a broad critical view of the various empirical and theoretical ideas and perspectives relevant to the study. It reviews, compares and contrasts the ideas of the various authors concerning the study in order to fairly and rationally broaden the horizon of the researcher and those who will read this thesis.

2.2 Theoretical Framework

The theoretical base of this study is embedded in the constructivists' theory of learning to the work of Ausubel, Piaget and Vygotsky (Ausubel, 1963, 1968; Piaget, 1964, 1970; Vygotsky, (1978). This tradition currently dominates research in Physics education. When teaching students, he/she comes to the classroom with his/her own prior knowledge on the subject matter to be taught. What is to be taught is based on the previous knowledge of the student. What this means is that the construction of new knowledge in Physics is strongly influenced by prior knowledge one possesses in the teaching and learning process. It is also a process where motivation and interest in the subject matter may increase or decrease for such construction to take place.

In the constructivist framework, one must pay attention to attitudes and interests within the teaching and learning process. The theoretical framework of this research, therefore, could be seen to be prepared on the principle that students construct their own meaning of new information on the basis of prior knowledge and that whatever is brought to the learning environment is necessary.

In constructivism, emphasis is on how actively students are engaged in creating their own understanding of concepts based on the previous knowledge and experiences they possess. Some students find it very difficult to grasp a concept even after it has been explained using the constructivist approach. In such cases, several approaches have to be employed to assist students to understand the concept. For instance, teachers have to recognize that students have varied learning needs and are able to adapt instruction accordingly based on this. Teachers have to provide additional teaching and learning resources, different explanations, and a lot of examples that can accommodate to different learning styles or abilities of the student. Furthermore, teachers can also teach one-on-one or in smaller groups to students who have difficulties in understanding a concept. This sort of approach makes the student's receive personalized attention and targeted support tailored to their specific needs.

Learning is not static, and understanding of a concept can take time and several strategies. Teachers should create a supportive and inclusive classroom environment where students feel comfortable to get help and ask questions. With ongoing support and employing various strategies, teachers can help students develop a deeper understanding of concepts even if they initially find it difficult to understand basic concepts.

2.2.1 Constructivism

Keengwe et al. (2014) defined constructivism as ''an educational theory that emphasizes hands-on, activity-based teaching and learning in which students develop their own frames of thought.'' According to Schultz (2015) generally constructivism "demands active participation and shifts responsibility from teachers to learners, the approach allows learners to form their own representations of knowledge as well as take more responsibility for their own learning."

Qarareh (2016) referred to constructivism as ''a process of receiving which involves learners' building of new meanings within the context of the current knowledge according to their experiences and learning environment.''

Zaitoon (2007) as cited (Qarareh, 2016) identified that constructivist learning consists of four corresponding stages, which adopted the constructivism theory to ease learner's construction of scientific concepts through mental processes, and each stage is closely linked to the next stage and the stages are:

a) Engagement or Invitation Stage

At the beginning of the educational situation, the teacher engages the learners in the new subject asks them questions in order to invite them to learn, think, motivate them, and create a knowledge-based environment to learn the subject, and figures out the ideas and knowledge necessary to learn a new subject.

b) Exploration Stage

This stage is the most important in the classroom, where the teacher divides the learners into heterogeneous groups; and each group carries out various activities such as collecting data and information, classifying them, develop hypotheses, ask questions, search for answers and explanations, access to solutions, criticize them, issue judgment; in preparation for social dialogue to reach solutions to the question raised at the beginning of the class. The teacher here is a facilitator who hears and raises additional questions.

c) Explanation Stage

At this stage, learners provide explanations, suggestions, propose solutions, and test the validity of these solutions based on their new experiences, as they build the new knowledge and link it to the previous one, or modify the previous knowledge and perceptions, and the teacher has to encourage learners to formulate their findings, give them enough time to put forward suggestions and interpretations, help learners, and facilitate the learning process.

d) Decision Making Stage

This step involves access to the appropriate solution to the problem and implementation of such solution. Hence, the cognitive integration process occurs between the new and previous concepts, which lead to cognitive integration of the concepts and the emergence of more extensive and deeper concepts. Consequently, this resulted in new construction of knowledge on the part of the learners, and application of what they have learned in new situations.

As this research is based on the constructivist theory of learning, the researcher believes that for students to be engaged in learning Physics these stages must be employed in the teaching and learning of Physics.

2.3 Engagement Theory

According to Kearsley and Shneiderman (1999), the major idea of engagement theory is the students must be meaningfully engaged in learning activities through interaction with others and valuable tasks. They pronounced that this kind of framework or theory is common with other theoretical frameworks for learning and that emphasis is on meaningful learning, that is, collaboration among peers and community of learners.

Conclusions drawn from their studies highlighted that engagement theory is consistent with constructivist methods as described in section 2.2.1.

Kearsley and Shneiderman (1999) posited three main means for engagement to be achieved, namely (1) an emphasis on collaborative efforts, (2) project-based assignments, and (3) non-academic focus. They also suggested that these three methods result in learning that is creative, meaningful, and authentic.

According to Miliszewska and Horwood (2006), the engagement theory is based on the knowledge of making successful collaborative teams that work on tasks that are meaningful to someone outside the classroom. They summarised the core principles as "Relate", which emphasizes characteristics such as communication and social skills that are involved in team effort; "Create", which regards learning as a creative, purposeful activity; and "Donate", which encourages learners to position their learning in terms of wider community involvement.

2.4 Learning Environments

Researchers have endeavoured to describe the educational context and to identify relationships between content, pedagogical practice, and environmental variables in learning environments (Fraser 2007; Vennix et al., 2017; Vennix et al., 2018). There is evidence that learning environment perceptions are linked to students' outcomes such as attitudes, interest, and cognition (Baeten et al. 2013; Kingir et al. 2013; Ogbuehi and Fraser 2007; Vennix et al., 2017). Several dimensions in science learning environments research have been suggested to describe the orientation of the learning environment and the effects on the attitude towards science and interest (Vennix et al., 2017).
Moos (1980) differentiated the three dimensions that describe the learning environment: relationship, personal growth, and system maintenance and change. The relationship dimension assesses the extent to which students are involved in the social and physical setting. The personal growth dimension refers to opportunities for personal development. The system maintenance and change dimension refers to the extent to which the environment is orderly, is clear in its expectations and responds to change. Vennix et al. (2017) postulated that, when all three dimensions are emphasised, both social and academic outcomes are enabled. A greater focus on one dimension can have

negative effects on student outcomes (Moos 1980). Most of the learning environment surveys constructed in the past have covered all three dimensions as suggested by Moos (Fraser 2007). Outreach learning environments major aim is to stimulate students for STEM (Vennix et al., 2017). According to Vennix et al. (2017), research on motivation suggests that the intrinsic type of motivation is related to the three dimensions or types of needs and this have been met through the learning environment.

The first type of dimension is the need for autonomy and denotes the extent to which students feel volitional in their decision to engage in academic activities (Pink 2010; Ratelle & Duchesne 2014). The second type of dimension is the need for competence and that denotes the extent to which students understand and have the relevant skills to succeed (Deci & Ryan 2000). The third type of dimension is the need for relatedness and denotes the need to establish significant and satisfying relationships with other students (Baumeister & Leary, 1995). Vennix et al. (2017) identified that if relatedness, competence, and autonomy are all the same and also possess a sufficient degree present, students become inspired intrinsically. Intrinsically motivated students are thought to possess a positive attitude towards STEM subjects and are more probable to choose to study a STEM subject or career in the future (Eccles 1983; Meece 1990; Vennix et al., 2017).

2.5 Meanings of Student Engagement

A body of research suggests the following meanings of student engagement. Axelson and Flick (2010) defined student engagement as "how involved or interested students appear to be in their learning and how connected they are to their classes, their institutions, and each other". Furthermore, Barkley (2010) as cited in Groccia (2018) defined student engagement as a "process and a product that is experienced on a continuum and results from the synergistic interaction between motivation and active learning." Barkley's definition is important for students to help in improving their learning and perceptions of their engagement (Groccia, 2018).

Some authors, such as Skinner and Belmont (1993), have associated student engagement with motivation saying that students who are engaged "show sustained behavioural involvement in learning activities accompanied by a positive emotional tone.” These students tend to select challenging tasks, show initiative in learning, demonstrate intense effort and concentration, and express positive emotions including enthusiasm, optimism, curiosity, and interest during learning.

According to the Glossary of Education Reform (2016, n. p.), a comprehensive online resource that describes school-improvement terms, concepts, and educational strategies, student engagement “refers to the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education.”

Student engagement refers to the manner in which students participate and involve themselves in the teaching and learning process and educational purposeful activities to enhance their interest (Taylor et al., 2011; Torto, 2020). Studies conducted by Fredricks et al. (2004) and Torto (2020) have reported three kinds of student engagement. Namely, affective, behavioural, and cognitive. All the three kinds of engagements are essential for the growth of the student. This means that for the students to be engaged with Physics all the three kinds of engagement should work together as a whole (Torto, 2020).

2.5.1 Types of Student Engagement

Affective engagement is defined as the kind of love one has towards people, for example, teachers, friends, and the teaching and learning activities (Pekrun & Linnenbrink-Garcia, 2012). In the teaching and learning of Physics, when students feel cared about their teachers and friends (classmates) they are optimistic and engage in meaningful learning. The love the students have for Physics creates a sense of belonging and helps the student to complete assignments (Connell & Wellborn, 1991; Finn, 1989; Finn & Zimmer, 2012; Fredricks et al., 2004, 2011; Sinatra et al., 2015; Skinner & Belmont, 1993; Schmidt 2017). The affective dimensions of Physics teaching and learning includes attitude, belief, perception, and interest related to Physics.

Behavioural engagement is defined as the way in which a person actively participates in educational activities with a greater amount of interest and tenacity (Birch & Ladd, 1997; Skinner & Belmont, 1993; Fredricks et al., 2004; Schmidt, 2017). Conclusions drawn by

Sinatra et al. (2015) cited in Schmidt (2017) showed that there is a link between behavioural engagement and achievement across various academic areas including science (Physics). The efforts Physics students show during lessons to enable them finish assignments given by their teachers is an example of behavioural engagement.

On the other hand, cognitive engagement is defined as ''a person's psychological and motivational investment he or she makes in academic activities'' (Connell & Wellborn, 1991; Newmann et al., 1992; Wehlage et al., 1989; Fredricks et al., 2004; Schmidt 2017). Several empirical studies, for example Wonglorsaichon et al., (2014), indicate proof of a correlation that exists between the three kinds of engagement and students performance. This research work does not focus on the correlation between the kinds of engagement. It seeks to investigate how students are engaged with Physics in Ghana. Hence, the correlation between the three kinds of engagement is not needed.

2.5.2 Students' Engagement with Science/Physics

One of the important goals of this study is to identify how students can be engaged with Physics in Ghana. Students' engagement with Physics is undergirded by the affective, behavioural, and cognitive factors of learning. This is because the whole being of the student is involved in use of knowledge. In other words, learning involves the affective, behavioural, and cognitive types of engagement and that they all play an equally important role in the use of knowledge. The student can only be motivated to engage in Physics if it is of interest and value to him/her.

Research shows that there has been an increase in students' engagement but only a small number of studies focus on Science/Physics. Several studies have identified low levels of students' engagement in Science/Physics and this has been on the decline over the years in schools (George, 2000; Gottfried et al., 2001; Greenfield, 1997; Osborne et al., 2003; Heflin & Macaluso, 2021).

Several studies in this domain has focused specifically on hands-on activities (practical work, experiment) and students' engagement in science. In this literature review, the focus on science will be related to Physics and treated as same. Cerini et al. (2003), in their study, conducted a survey of 14-19 year olds in the UK and identified that 71%

pronounced that they are excited when it came to doing science experiments and the methodology used for the teaching and learning was found enjoyable (Cerini et al., 2003; Hampden-Thompson & Bennett, 2013)

Hampden-Thompson and Bennett (2013), in their study, found that students who wants to pursue science-related careers have higher engagement in science and also students have future aspirations and are motivated in science. A strong support from this finding comes from the work of DeWitt and Osborne (2008) which revealed that certain classroom activities were more likely to encourage and stimulate students to pursue science at higher levels of study –in the case for Ghana and particularly for this study, the SHS, CoE and Universities. The activities that engaged and motivated the most were those that required greater amount of independent learning, group work with classmates, and continuous collaboration with students' overseas and active hands-on activities which were extended outside the scope of one lesson (Hampden-Thompson & Bennett, 2013). The teaching and learning process in Physics involves a lot of experiments and hands-on activities.

Kuh (2003) identified that student engagement measures the time and effort students use in participating in academic and extracurricular activities. Students tend to gain more from their collegiate experiences when they devote more time and energy to purposeful academic activities, such as frequently interacting with various people and applying what they have studied to solve real-world problems (Kuh, 2003).

A study by Pike and Kuh (2005) examined 3,000 undergraduate students in the U.S. and made comparison to the engagement and intellectual development of first-generation and second-generation college students. Furthermore, Pike and Kuh (2005), in their study, revealed that first generation students had low engagement in college life, inadequately integrated into diverse college experiences, and perceived their college environment as less helpful.

2.6 Attitude Towards Physics

Attitudes towards the teaching and learning of Physics is an important concept that can be described as the teachers' and students' view of knowledge, assessment, learning activities (for example laboratory activities, hands-on activities, experiments/practical etc.) and the roles played by students and teachers during the teaching and learning process.

Understanding of student attitude is imperative in supporting their interest towards a particular discipline (Jebson & Hena, 2015). Attitudes are psychological constructs theorized to be composed of affective (emotional), cognitive, and behavioural components. Attitudes serve as functions including social expression, value expressive, utilitarian, and defensive functions for the people who hold them (Newbill, 2005). To change attitudes, new attitudes must serve the same function as the old one. Attitudes are connected to social cognitive learning theory as one of the personal factors that affect learning (Bandura, 1997; Newbill, 2005). Attitude towards science was defined by Mabee et al. (2021) as ''a favourable (positive) or unfavourable (negative) feeling about science as a school subject''. Students can therefore express their feelings, either positive or negative, towards the learning of a science subject. Attitudes toward Physics is an important concept that can be described as the students' view of knowledge, assessment, laboratory activities and the roles of instructors and students.

George (2006) cited in Olasimbo and Rotimi (2012) agreed with the assertion that attitude is comprised of two component parts which are affective in dealing with mental process. The kind of attitude builds up by students influence their learning abilities in a particular subject. Physics is considered as the most problematic area within the realm of science, and it traditionally attracts fewer students than chemistry and biology (Rivard & Straw, 2000 cited in Olasimbo & Rotimi, (2012). Physics is perceived as a difficult course for student from secondary school to university and for adults in graduate education. It is well known that both high school and college students find Physics difficult. Research has shown that the attitude towards science change with exposure to science, but the direction of change may be related to the quality of that exposure, the learning environment and teaching method (Cracker, 2006 cited in Olasimbo & Rotimi, 2012). Akinbobola (2009) suggests that the attitude of students is likely to play a momentous part in any satisfactory explanation of variable level of performance shown by students in their school science subject. Ogunleye cited in Akinbobola (2009) in his findings pronounced that many students developed negative attitudes to science learning, probably since teachers are unable to satisfy their aspiration or aims. In addition, Akinbobola (2009) showed that there is positive relationship between attitudes and performance in the science subjects.

2.6.1 Students' Attitudes Towards the Learning of Science/Physics

The attitudes of students towards the study of Physics and their interest for the subject is essential as students engage with Physics. Education in its general sense is a form of learning in which the knowledge, skills, and habits of a group of people are transferred from one generation to the next through teaching, training, and research. Any experience that has a formative effect on the way one thinks, feels, or acts may be considered educational. Education from all perspectives is viewed or aimed at preparing one for life and since it is supposed to prepare one for a better living, one must be certain on what he/she can achieve through it and from what discipline he/she can attain it. Education must draw some of its principles from psychology. This entails having good grasp of all theories that influence the teaching and learning process. Also, the quality of education that a teacher provides to students is highly dependent upon what teachers do in the classroom. Thus, preparing the students of today to become successful individuals of tomorrow, science teachers need to ensure that their teaching is effective. Understanding of student attitude is very important in supporting their achievement and interest toward a particular discipline (Physics). Students attitude toward science have been extensively studied, but research was initially focused greatly on science in general (Dawson, 2000; Osborne et al., 2003) and less attention was addressed to disciplines like Biology, Physics and Chemistry (Salta & Tzougraki, 2004). This can partly camouflage students' attitudes because science is not viewed as homogenous subjects. Therefore, identification and influence of attitudes came to be an essential part of educational research.

It is generally believed that students' attitude towards a subject determines their success in that subject. In other words, a favourable attitude results in good achievement in a subject. A student's constant failure in a school subject can make him/her to believe that he/she can never do well on the subject; thus, accepting defeat. On the other hand, his/her successful experience can make him/her to develop a positive attitude towards learning the subject. This suggests that student's attitude towards science subjects could be enhanced through effective teaching strategies. It has been confirmed that effective teaching strategies can create positive attitude on the students towards school subjects (Olowojaiye, 2000). A student's attitude is related to all the facets of education. For example, the attitude of a student towards science will determine the measure of the students' attractiveness or repulsiveness to science. It follows therefore, that to have better students' performance in science subjects there is need to determine students' attitude to science subjects (Sofeme & Hena, 2015).

Olatoye (2002) found that students' attitude towards science has significant direct effect on students' achievement in the subject. Adesokan (2000) asserted that despite the recognition given to Chemistry among the science subjects, it is evident that students still show negative attitude towards science subjects; thereby leading to poor performance and low enrolments. Ivowi (1997) established that in Nigeria, students' poor performance in Physics has been attributed to poor teaching methods, unqualified and inexperienced teachers, poor students' attitude towards Physics, poor learning environment, and gender effects.

The attitudes of students towards the studying of Physics consist of ways in which they find solutions to problems. Students studying Physics should possess competent skills which would help them to understand concepts in science (Darmaji et al., 2018; Astalini et al., 2019). During the teaching and learning process in the classroom, students are able to acquire these skills to enable them to be engaged in learning Physics.

Students who possess positive attitudes towards the learning of Physics usually have fun during the teaching and learning process. This type of pleasure that the students are engaged in have enormous behaviour in the way they learn (Manasia, 2015; Astalini et al., 2019). Furthermore, students who possess fun for studying Physics improves their performance which makes them to be interested in studying science (Ainley, 2011; Astalini et al., 2019).

Intrinsic and extrinsic motivation influences students delight to actively participate and involved in studying Physics. It is a good idea for teachers to reward (for instance, receiving a prize) their students for their achievements, for example, scoring excellent marks in class, quizzes, assignments, and exams (Higgins & Kruglanski, 2000; Astalini et al., 2019). Teachers should be able to motivate their students to be interested in Physics in this way.

The attitudes of students change with respect to time (Erdemir & Bakirci, 2009; Guido, 2018). This means that attitude is dynamic and not static. This also implies that attitudes of students learning Physics will not be the same but change over time as they continue to study.

2.6.2 Teachers' Attitudes/Motivation Towards the Teaching of Science/Physics

Several studies (for example, Crawford 2000; King et al., 2001; Souza Barros & Elia 1997; DiBiase & McDonald, 2015) have confirmed that the attitudes of teachers towards the teaching and learning of Physics/science is significant in Physics education research and educational research in general. One of the objectives of this research is to determine the kind of attitudes teachers have towards the teaching of Physics.

Kunter et al. (2008) defines enthusiastic teaching as a "particular effective mode of delivering information to students" and describes teachers' method of teaching and generally energetic, animated, and inspiring way of teaching (Murray, 2007).

In a study by Gess-Newsome (2013) and Keller et al. (2016), they indicated that teachers' pedagogical content knowledge (PCK) is one of the most influential factors contributing to students' learning and achievement. How a Physics teacher teaches the content of Physics to his/her students is very important which contributes to students' interest in Physics. The motivation of a Physics teacher is very essential for students to be engaged with Physics. Teachers' motivation depends on the teaching methods they use and their students' performance. A strong support for this is the findings from the work of Kunter et al. (2013) and Schiefele & Schaffner (2015), that suggest that teachers' motivation determines their instructional conduct and resultantly students' results (Keller et al., 2014; Kunter et al., 2013; Keller et al., 2016). Potvin and Hasni (2014) allude to this fact for which empirical evidence has been provided in science subjects for example Physics, Biology, Chemistry etc. (Keller et al., 2016). The motivation the teacher has also affects the students' performance and their attitudes towards the learning of Physics.

Research studies have indicated that many teachers have low mastery of the subject matter knowledge in science, and this has affected their attitudes. Hence, these teachers possess negative attitudes towards the teaching of science (Nilsson & van Driel, 2010). Osborne et al. (2003) cited in Nilsson and van Driel (2010) asserts that individuals have various forms of attitudes towards science. Therefore, the sort of attitude that a teacher possess can be positive or negative. Teachers are able to deliver their lessons confidently and effectively when they have mastery of the subject knowledge, this would enable them to be able to explain the science content to the students very well for them to understand (Childs and McNicholl 2007; Nilsson & van Driel, 2010). In addition to this, according to research by Childs and McNicholl (2007), they examined the relationship that exist between mastery of the subject matter knowledge of single science teachers in secondary and their pedagogic practice.

2.7 Choices/Decisions Made by Students to Study Physics

In a study by Schmidt et al. (2017), they examined the influence of a number of choices that occur on high school students' temporary engagement. The specific aim of their research was to observe how specific learning activities and how students' choice relates to their engagement in high school science classrooms. The choice of the students is very important to how students can engage in meaningful learning. Science/Physics teachers have to identify ways in which they can use instructional periods to fully engage their students in Physics.

Hampden-Thompson and Bennett (2013), in their study, found that in order to find solutions to the problem of increasing the number of science after necessary schooling it is substantial to understand student engagement in science and the factors that have impact on it.

Olitsky et al. (2010) cited in Abe and Chikoko (2020) posit that the values, activities, and attitudes of friends of students may have an impact in the manner a young person decides and choose a particular course. Sjøberg and Schreiner (2005a) attest to the fact that the economic significance for a country to have a high number of skilled scientists and engineers is well acknowledged. Nonetheless, young people do not choose their studies or careers because it is good for the economy of their country, especially for a country where young people have such choices. They do so based on their own interests, values, and priorities. It is therefore imperative that the studying of Physics reflects to adequately prepare students for societal demands (Abe & Chikoko, 2020).

2.8 Relevance of Physics

Physics is one of the most essential subjects in science education courses. It is taught in high schools as one of the mandatory subjects to gain knowledge and for students to further study it at colleges and universities to be applied in courses, for example, engineering, pharmacy, medicine, and dentistry (Srisatjaluk et al., 2018). Evidence has been provided by Srisatjaluk et al. (2018) that the fundamental sciences such as Physics is useful for medical students.

The knowledge gained in Physics is needed by medical students to understand basic concepts of clinical instructions (Pangaro, 2010; Woods et al., 2005; Srisatjaluk et al., 2018). Srisatjaluk et al. (2018) affirmed that the fundamental sciences such as Physics should taught in the syllabus of medical students to broadly improve their knowledge and skills.

In a study conducted by Srisatjaluk et al. (2018), the attitudes of students towards science (Physics) is related to the perceptions on the relevance of science (Physics) which can be applied in their everyday lives (Stuckey et al., 2013; Zavala et al., 2015). According to Zavala et al. (2015), attitudinal studies rarely placed great emphasis on the relevance of students' career decisions.

The extent to which students understand how Physics relates to the real world and its connection to various jobs may vary among students. It is significant for teachers to stress the practical applications of Physics and aid students make connections between Physics and real-world situations. There are several factors that can influence students' understanding of the relevance of Physics to the job market (see Chapter five). Educators can help students better understand how Physics is connected to the real world and the wide range of job opportunities available to those who study Physics. It is crucial to emphasize the relevance and applicability of Physics to motivate and inspire students in their learning journey.

2.9 Awareness of Careers in Physics

Recent study by Institute of Physics (IOP) apprenticeships research highlighted the lack of STEM apprenticeship careers. There is a lack of apprentices in Physics related positions and the report discovered that there are problems held by young people (Institute of Physics, 2023; Abe & Chikoko, 2020).

In an exploratory study by Abe and Chikoko (2020), they described the various ranges that students' perceived decisions-making and their experience with regards to careers. They found that the impact of the role their families, personality and expectations played in towards deciding on a career among many South African university students. This shows that the decision of a student to choose a career in Physics may be associated with the inspiration they have from their families, personality and their own expectations.

Researchers (for example, Clotfelter, Ladd, & Vigdor, 2007; Rivkin, Hanushek, & Kain, 2005) have confirmed that teachers have a solid impact on the decisions made by students (Abe & Chikoko, 2020). A recent study by Wrigley-Asante et al. (2022) examined the career aspirations of students learning STEM subjects and the factors that influence them. Their findings indicated that male and female career aspirations were virtually the same. Furtherance to that, conclusions drawn from their research shows that students who choose to study a STEM career may face financial difficulties, doubts and rise in unemployment in the job market in Ghana.

According to Astalini et al. (2019), the learning results of students and their attitudes towards learning Physics have an impact with a career in Physics. In addition, they also assert that students who perceive Physics as a difficult subject, also perceive careers in Physics to be difficult. Hence, these students are not interested in careers that involves Physics. The challenges faced by students in Physics makes them not to enjoy careers in Physics (Astalini et al., 2019).

A survey was conducted by Parisi et al. (2023) on high school students on how they perceived careers that involves Physics. They found that there were various careers that involves Physics that students were not aware of. They also reported that Physics careers that were perceived by students have a main influence on whether they would decide to choose Physics as a profession.

A learner's experience in Physics has a major impact on their decision to pursue Physics professionally. This decision can also be influenced by a high school student's awareness of issues concerning diversity within the Physics community (Parisi, et al, 2023). Parisi et al. (2023) surveyed current high school Physics students and investigated their perception of Physics careers and knowledge of diversity issues within the field. When they explored student responses, they found that students are generally unaware of the variety of careers available within Physics. In addition, they saw that many students are uninformed about issues regarding diversity within the Physics community. Furthermore, they found that Physics teachers can have a noticeable impact on how students perceive these issues

2.10 Impact of Outreach Activities on STEM Education

According to Vennix et al. (2017), education is changed by placing emphasis to promote attitudes in STEM and increase the uptake of students to choose STEM subjects and careers in many nations (Bettinger 2010; Krapp and Prenzel 2011; OECD 2006). They added that greater emphasis should be given to twenty-first century skills that will place emphasis on the connection between knowledge gained in the classroom with the outside world (Krapp and Prenzel 2011; IOP Accreditation, 2022).

Studies have shown that there has been an enormous amount of increase of outreach activities for students of all ages internationally and in the UK with the focus on STEM (Aslam et al., 2018; Vennix et al., 2017). Examples of STEM outreach activities in the UK include STEMNET, the STEM Learning Centre and Network. Their aim is to coordinate the activities of outreach in the UK and assist teachers to be able to form STEM clubs (Aslam et al., 2018). Another outreach provider in the UK is the Ogden Trust with the aim to increase the number of post-16 students in Physics in the country. They also work in partnership with other stakeholders to create awareness and help teachers in their professional development. Another aim of the trust is to assist students to understand the perceptions of the relevance of studying Physics and what it means to be a Physicist (Ogden Trust, 2019).

One of the outreach activities in Africa is the Astronomers Without Borders (AWB) in Nigeria. AWB engages in a lot of outreach activities. It is one of the leading Astronomy Education Outreach in Nigeria and is helping to bridge gaps within the system of education because at the basic and high schools in Nigeria, Astronomy is not taught (Olayinka, 2022), this is the same for Ghana, hence consistent with what Okwei et al. (2022) reported. According to Olayinka (2022), AWB uses astronomy to motivate children and to continue STEM education in their schools, enrol and inspire them in STEM.

Over the past years, there have been several outreach activities in Ghana. Several studies (for example, Arrigoni-Battaia, et al., 2018; Aworka et al., 2021; Hoare, 2018; Okwei et al., 2022; Trebi-Ollennu & Okraku-Yirenkyi, 2014; Strubbe et al., 2021) confirm this. These outreach activities have played a critical role in increasing the motivation of students' uptake in STEM subjects and careers.

According to Trebi-Ollennu & Okraku-Yirenkyi (2014) the Institute of Electrical and Electronic Engineers (IEEE) Control Systems Society (CSS) organizes outreach activities to motivate students in the uptake of STEM subjects and careers (Trebi-Ollennu & Okraku-Yirenkyi, 2014).

There have been an increasing number of students who are talented in Africa and these students are curious about science. To help these students to achieve this they need to be inspired and be supported to offer STEM careers (Strubbe et al., 2021). In Ghana, various outreach activities have been funded by DARA which aims at inspiring students in astronomy and the increase in the uptake of STEM courses for development (Hoare, 2018). Conclusions drawn from a recent study by Okwei et al. (2022) appear to be consistent in the findings of earlier researchers. The intervention they introduced helped to play a critical role for students to be interested and increase their uptake in STEM subjects. In Ghana, the government announced programmes to increase the uptake of STEM subjects in schools. Hence, stakeholders have been tasked to employ more science students in the system of education (Ibrahim & Seker, 2022).

Turner et al. (2007) as cited in Aslam et al. (2018) suggests that the learning environments that are embedded within outreach activities should exhibit the significance of STEM and be able to stimulate and intrigue students to study STEM subjects beyond necessary schooling.

2.11 Identification of Gaps in the Research

The above review of related literature presents studies carried out in different parts of the world, on matters pertaining to constructivism, engagement theory, learning environments, meanings of engagement, types of engagement, students' engagement with science/Physics, attitude towards physics, students' attitudes towards the learning of science/Physics, teachers' attitudes/motivation towards the teaching of science/Physics, choices/decisions made by students to study Physics, awareness of careers in Physics, relevance of Physics, and impact of outreach activities on STEM Education. These studies have been carried out in other countries, but not in Ghana. This study aimed to fill the missing knowledge gap on student's engagement with Physics in Ghana with the information and data obtained from teachers and students from Ghana.

Whereas Wonglorsaichon et al. (2014), Gunuc (2014) and Reyes et al. (2012) found out that there was a correlation between the dimensions of student engagement and achievement, other studies that took place in Ghana looked at aspects (emotional) of students' engagement. None of these studies sought to find out students' engagement with Physics in Ghana. This study, using science and Physics teachers and their students as participants, is therefore different from other studies in that, this study sought to find students' engagement with Physics in Ghana.

Research studies and theory on student engagement has increased in the past decade, only a small number of studies have focused specifically on the field of Physics. To address these gaps in this study, the aim of this study is to find out how students are engaged with Physics in Ghana. Hence, identifying ways in which Physics/Science teachers have used instructional periods to engage their students in Physics. Furthermore, comparisons of interests and attitudes towards Physics between African countries and other parts of the world are missing. There is, at least, an obvious gap to be bridged here. This study hopes to address that.

2.12 Summary of Literature Reviewed

The study was based on the constructivist's theory of teaching and learning. In the literature review, it was seen that constructivism theory basically concerns learning and not teaching. The emphasis is therefore laid on the learning environment and it is learner-centred rather than the teacher-centred. Emphasis was also placed on students' engagement with Physics, for that matter for students to be meaningfully engaged in Physics they have to participate and involve themselves in learning activities through interaction with others and valuable tasks. The teacher's role is to ask ''what should be taught'' and ''how this can be learned'' (Proulx, 2006). Henson (2003) also cited some of the benefits of learner-centred education put forward by Dewey as including students' have increased intellectual curiosity, creativity, drive, and leadership skills. Teachers who are committed to learner-centred education do challenge students within their abilities while providing reinforcement and appropriate rewards for students' success.

Chapter 3 : Methodology

3.1 Overview

The chapter describes the research design used for the study. It also describes the population, sampling and sampling procedure, instrumentation and description of validity and reliability of the instrument. The chapter ends with the description of data collection procedures used and the methods of data analysis.

3.2 Research Design

Burns and Grove (2003) defined a research design as:

> *“a blueprint for conducting a study with maximum control over factors that may interfere with the validity of the findings.”*

Parahoo (1997) describes a research design as:

> *“a plan that describes how, when and where data are to be collected and analysed.”*

Polit, Beck and Hungler (2001) also defines a research design as:

> *“the researcher’s overall plan for answering the research question or testing the research hypothesis.’’*

In this study, a mixed methods comparative research design was used. This design sought to integrate both qualitative and quantitative data in a single study and therefore results in a more complete understanding of the phenomenon under examination. This is a problem-centred technique to research in which methods and theories have been used instrumentally, based on their applicability to the present study. The researcher employed this design because the mixed method design values both qualitative and quantitative approaches to research. These approaches are suitable to the researcher because his purpose is to describe, explain, or evaluate, and are particularly advantageous for studying complex problems or issues (Leavy, 2017d).

Thomas (2017) defined the term comparative study as ‘’the comparison of a social situation in a country.’’ According to Thomas (2017) it also refers ‘’to cross-national comparison with the aim of gaining insights from the comparisons.’’ For the purpose of this research the comparative study was about comparison between DARA teachers and their students and Non-DARA teachers and their students in Ghana. The researcher decided to use comparative study because of the following reasons:

Firstly, new visions can be obtained: educational and social thought can develop in a limited way in particular environments and the recognition that another population (teacher/students) does things differently can offer new avenues for ideas and for development (Thomas, 2017).

Secondly, potential clarifications may occur for the existence of particular developments in behaviour, in understanding or even in institutional development or decline in a particular place, based perhaps on historical or cultural differences (Thomas, 2017).
Thirdly, they give us a window on our own unspoken and unquestioned cultural anticipations when these are seen against the backdrop of the expectations and practices of others (Thomas, 2017).

Finally, the challenging differences that occur during analysis of different cultural situations can themselves provide insights (Thomas, 2017).
The study was conducted in the form of a cross-sectional study. In a cross-sectional study groups are studied at equal times. One variable may be looked at, providing a descriptive picture, or two or more variables, to see a relationship among them (Thomas, 2017).The research was about evaluating an intervention (namely DARA's training programme for teachers) and its impact on students' engagement with Physics and teachers' attitudes in Ghana. The researcher compared participants who have experienced the intervention (DARA teachers and their students) with those who have not (Non-DARA teachers and their students).

3.3 Qualitative and Quantitative Research

According to Leavy (2014) qualitative research: is usually characterised by inductive methods to knowledge construction aimed at generating meaning; is used to learn about a social phenomenon; robustly unpack the meanings people ascribe to activities, situations, events, people, or artefacts; or build a depth of understanding about some dimension of social life (Leavy, 2014).

Qualitative research results in a depth of understanding (detailed information from a small sample) and is usually appropriate when the main purpose is to explore, describe, or explain. The researcher focused on the experiences from the participants' perspective. The researcher's involvement in the study added to the uniqueness of data collection and analysis (Streubert & Carpenter, 1999). The rationale for using a qualitative approach in this research was to explore and describe the opinion. A qualitative approach was also appropriate to capture the opinions of the teachers and students on certain topics to gain more insight. It one or the other deemed most effective to undertake semi-structured interviews with the teachers, as there is smaller number of them, as the researcher really wanted to gain in-depth understanding of how DARA has affected their teaching and how they perceive it has affected their students.

Leavy (2017d) posits on the other hand that quantitative research is characterised by deductive methods to the research process meant to disprove or lend credence to existing theories; it involves measuring variables and testing relationships between variables in order to disclose patterns, correlations, or causal relationships and results in statistical data (generally from a large sample). Quantitative data allowed for numerical comparisons to evaluate the degree to which the DARA teachers and their students, and the Non-DARA teachers and their students differ. The most efficient way to get data from such a large number of students is to use a questionnaire containing quantitative and qualitative responses.

3.4 Profile of the Research Area / Environment

Ghana is in the sub-region of West Africa and situated along the Gulf of Guinea and the Atlantic Ocean. It has a land mass of 238,535 km^2 (92,099 sq mi), Ghana is surrounded by the Ivory Coast in the west, Burkina Faso in the north, Togo in the east and the Gulf of Guinea and Atlantic Ocean in the south. The meaning of Ghana is "Warrior King" in the Soninke language. The first permanent state in the territory of modern Ghana dates back to the 11th century. Many kingdoms and empires have emerged over the centuries, of which the most powerful was the Ashanti Kingdom. Beginning in the 15th century, many European powers contested the area for trading rights, with the British ultimately establishing control of the coast by the late 19th century. Following over a century of native resistance, Ghana's current borders were established by the 1900s as the British Gold Coast. Ghana gained independence on 6th March, 1957.

The population of Ghana is approximately 30 million with varying ethnic, linguistic and religious groups. According to the 2010 census, 71.2% of the population was Christian, 17.6% was Muslim, and 5.2% practised traditional faiths. Its varied topography and ecology ranges from coastal savannahs to tropical rain forests. Ghana is a unitary constitutional democracy led by a president who is both head of state and head of the government. Ghana's economic growth success and democratic political system have made it a regional power in West Africa. It is a member of the Non-Aligned Movement, the African Union, the Economic Community of West African States (ECOWAS), Group of 24 (G24) and the Commonwealth of Nations.

3.5 Population of the Research Sample

Leavy (2017d) defined population as ‘’a group of elements about which the researcher might later make claims.’’ The population for the study was all teachers and students across Ghana. The target population for the study was all the JHS/SHS/University/College students and teachers in the Ghana that study and teach Physics/Integrated Science (Physics aspect) as a subject. The accessible population was all DARA trained and Non-DARA trained teachers and students in Physics in Ghana. Participating schools and teachers were identified by the researcher through the target teachers and schools he knew and the good relationship he had with the teachers and schools. The scope of the study was focused on all JHS and SHS of DARA trained and Non-DARA trained teachers and their students. The study was conducted in the Greater Accra and Central Region (Komenda) of Ghana. Greater Accra, is the capital city of Ghana, and Komenda, is a town in the Central Region. These two locations where the study was conducted have some differences in terms of schools, students and teachers due to factors such as location, population size, and available resources etc. Here are some potential differences between schools, students and teachers in Greater Accra and Komenda:

- Infrastructure and Facilities: For schools in Accra, being a larger urban area, students and teachers have better infrastructure compared to schools in Komenda. This can include larger and better-equipped classrooms, libraries, science laboratories, computer labs, and sports facilities. In Komenda, while schools have basic facilities, there are limitations in terms of resources and infrastructure.

- Class Sizes and Student/Teacher Diversity: Due to the larger population and higher number of schools in Accra, class sizes in some schools may be larger compared to those in Komenda. However, this can also depend on the specific school and class. The size and diversity of student and teacher populations vary between Accra and Komenda. Accra's larger urban setting exposes students and teachers to greater diversity in terms of cultures, languages, and perspectives. Students and teachers in Accra interact with peers and colleagues from different backgrounds, which contributes to a broader understanding of diversity and different ways of thinking. This presents unique challenges and opportunities for students and teachers. In Komenda, schools may have smaller class sizes and the student population is more homogeneous leading to a different cultural and social environment. Students in Accra come from a broader range mix backgrounds, including families with higher incomes and greater access to resources.
- Availability of Resources: Schools in Accra have better access to educational resources, such as textbooks, teaching aids, technology, and supplementary materials, due to being the capital and largest city with more resources and opportunities for collaboration. Students and teachers in Accra have more access to teaching and learning resources, materials, and technology due to the availability of educational institutions, libraries, and other learning centres (for example science resource centres etc.). This contributes to more diverse teaching approaches and materials. Teachers in Komenda may have to be resourceful and creative in utilizing the available resources effectively (improvisation).
- Exposure to Educational Opportunities: Accra generally offers more educational opportunities due to a higher concentration of educational institutions, libraries, and learning centres. Schools in Accra, being in a larger urban centre, offer more opportunities for students to engage in extracurricular activities, competitions, and cultural events. They have more partnerships with external organizations

and institutions for educational programs and field trips. Students and teachers in Accra may have greater access to extracurricular activities, cultural events, specialized educational programs, and resources. In Komenda, students and teachers have a more limited range of opportunities, but there are still dedicated teachers and initiatives to support their education.

- Community Involvement and Family Support: While both Accra and Komenda communities can be involved in supporting local schools, the level of community involvement and family support within the schools for students differs. In smaller communities like Komenda, there is a stronger sense of community support and engagement in school activities. Students in Accra may also have access to a wider range of support systems, such as tutoring services, mentoring programs, and career guidance due to the availability of resources.
- Experience and Qualifications: Teachers in Accra have greater access to professional development opportunities, workshops, and training programs due to the larger urban area. This could result in a higher concentration of experienced and highly qualified teachers. However, it's important to note that there are also dedicated and qualified teachers in Komenda who contribute significantly to education.
- Exposure to Pedagogical Trends: Teachers in Accra have more exposure to current pedagogical trends, teaching methodologies, and educational research due to the proximity to educational institutions, conferences, and professional networks. This influence their teaching practices and adoption of innovative approaches. However, teachers in Komenda can also stay updated through professional development programs and collaboration with other educators.

It's important to note that these differences are general observations made by the researcher and may not apply uniformly to all schools, students and teachers in Accra and Komenda. There may be variations within each location, and individual schools, students and teachers may have their own unique characteristics, teaching methods, strengths, and challenges.

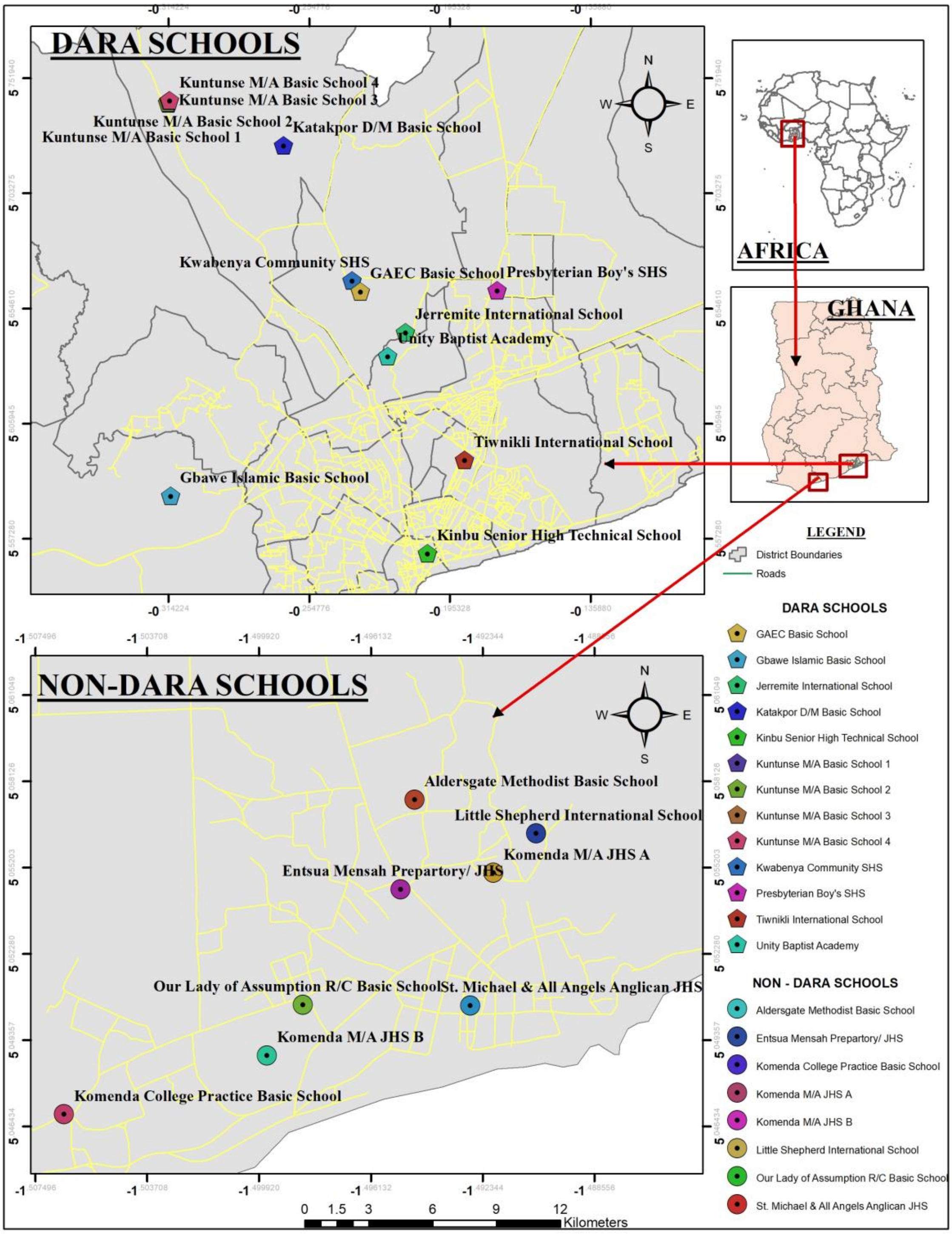


Figure 3.1: Map showing how the schools for the study are distributed geographically

3.5.1 Sampling Technique and Sample Size

Leavy (2017d) defined sampling as ''the process by which a number of individual cases are selected from a larger population, thereby determining who or what is in the study.'' The sample for the study consisted of a selection of the DARA trained teachers and their students and Non-DARA trained teachers and their students. The final participant sample was made up of 902 students and 21 teachers studying and teaching

Physics/Integrated Science (Physics aspect) as a subject. The sampling technique used for the study was purposive and opportunistic on the premise that the researcher focused on the teachers he knew, had good relationships with, had access to (both teachers and students) and were willing to participate in the study.

Table 3.1: Sample of the population for the study

Item	DARA	Non-DARA	Total
Teachers	13	8	21
Students	610	292	902
Schools	13	8	21

3.6 Identification of Research Participants

In order to preserve the anonymity of the participating teachers and their students, the study used pseudonyms to refer to the 21 teachers and their students that took part in the study as stated in Table 3.2:

Table 3.2: Information of DARA teachers that were interviewed

DARA Teacher	Pseudonym	Gender	School
1	Gab	Male	Kwabenya Community SHS GAEC Basic School
2	Mirek	Male	Presbyterian Boys' SHS-Legon
3	Geo	Male	Presbyterian Boys' SHS-Legon
4	Nesto	Male	Kuntunse M/A Basic School 1
5	King	Male	Jeremite International School
6	Zeb	Male	Tiwnikli International SHS
7	Kat	Female	Kuntunse M/A Basic School 2
8	Ceph	Male	Katapor D/M Basic School
9	Bunya	Male	Gbawe Islamic Basic School

10	Saddi	Male	Unity Baptist Academy
11	Debbie	Female	Kuntunse M/A Basic School 3
12	Patty	Female	Kuntunse M/A Basic School 4
13	Wise	Male	Kinbu Senior High Technical School

Table 3.3: Information of Non-DARA teachers that were interviewed

Non-DARA Teacher	**Pseudonym**	**Gender**	**School**
1	Esh	Male	Aldersgate Methodist Basic School
2	Freda	Male	Komenda College Practice Basic School
3	Maurice	Male	Komenda M/A JHS A
4	Elis	Male	Little Shepherd International School
5	Bismaro	Male	Entsua Mensah Preparatory/JHS
6	Hannab	Female	Komenda M/A JHS B
7	Aaro	Male	St. Michael & All Angels Anglican JHS
8	Chant	Female	Our Lady of Assumption R/C Basic School

Table 3.4: Research Participants (The table below indicates the nature of the research participants).

School Number	Institution / Schools (DARA Schools)	Category	Region	Government/ Private School	Teacher Interview (Yes/No)
1	Tiwnikli International SHS	SHS	Accra	Private	Yes
2	Presbyterian Boys' SHS-Legon	SHS	Accra	Government	Yes
3	Kinbu SHS (Technical)	SHS	Accra	Government	Yes
4	Kwabenya Community SHS	SHS	Accra	Government	Yes
5	GAEC Basic School	JHS	Accra	Government	Yes
6	Kuntunse M/A Basic School 1	JHS	Accra	Government	Yes
7	Kuntunse M/A Basic School 2	JHS	Accra	Government	Yes
8	Kuntunse M/A Basic School 3	JHS	Accra	Government	Yes
9	Kuntunse M/A Basic School 4	JHS	Accra	Government	Yes
10	Katapor D/M Basic School	JHS	Accra	Government	Yes
11	Gbawe Islamic Basic School	JHS	Accra	Private	Yes
12	Unity Baptist Academy	JHS	Accra	Private	Yes

13	Jeremite International School	JHS	Accra	Private	Yes
School Number	**Non-DARA Schools**				Yes
1	Little Shepherd International School	JHS	Central	Private	Yes
2	Komenda College Practice Basic School	JHS	Central	Government	Yes
3	Komenda M/A JHS A	JHS	Central	Government	Yes
4	Komenda M/A JHS B	JHS	Central	Government	Yes
5	St. Michael & All Angels Anglican JHS	JHS	Central	Government	Yes
6	Aldersgate Methodist Basic School	JHS	Central	Government	Yes
7	Entsua Mensah Preparatory/JHS	JHS	Central	Private	Yes
8	Our Lady of Assumption R/C Basic School	JHS	Accra	Government	Yes

Table 3.5: School Type (The table below shows the number of school type: Government/Private schools for the participants: DARA/ Non-DARA teachers and students).

Participant	Government School	Private School	Total
Dara teachers and students	10	3	13
Non-DARA teachers and students	6	2	8

3.7 Research Instrument

Two main instruments were used in the study: questionnaire and interview. A questionnaire was employed with the students and interviews were conducted with the teachers. These instruments are described in the following sections.

3.7.1 Questionnaire

Leavy (2017d) defined questionnaires as ‘’a primary data collection tool in survey research.’’ A Questionnaire is made up of the questions related to the subject under study. It has an advantage of being more efficient than observation. It has a wide range coverage and greater assurance of anonymity. I was introduced to the students by their teachers and explained the rationale for the research before I distributed and collected the questionnaires. The researcher created and printed a questionnaire and administered to the students to answer. Both closed and open-ended question types were used. In the closed questions the students were required to select from list of options, while in the open-ended questions, respondents were required to write their views on the questions. The questionnaire was divided into two sections. The first section that is Section A was designed to seek for background information of the respondents in respect of sex, age and school. The second section, Section B sought information from respondents on their attitudes towards Physics, relevance of Physics, reasons to choose to study Physics, career aspirations in Physics, and awareness of the Ghana Radio Astronomy Observatory (GRAO) telescope / Development in Africa with Radio Astronomy (DARA) project in Ghana.

The questionnaire had 44 questions that included 24 Likert scale questions, 15 open-ended questions and five yes/no/not sure questions. The Likert scale had closed questions in which respondents were presented with five response categories ranging from 'strongly agree' to 'strongly disagree'. In closed questions of this type, research participants were expected to choose their answers from categories that were presented to them (De Leeuw et al., 2008) (Appendix 1).

Closed questions formed the bulk of the questionnaire since they are easy to supervise and quick to analyse (Dawson, 2002). Open questions in the questionnaire were used in order to capture a large variety of responses. Open-ended questions are useful whenever a large number of answers to the categories cannot be accommodated using closed questions (Cohen et al., 2007). In addition, open-ended questions provide a flexibility that enables research participants to come up with topics that are pertinent to the research conducted (Roulston, 2008) (Appendix 1).

The advancement of the questionnaire instrument was an iterative process, initially drawn on existing instruments described in section 3.7.1.1 and on a widespread body of qualitative literature (Dewitt et al., 2013). For example, earlier research reflects the role played by the attitudes of children towards school science might show in the development of science aspirations. Consequently, a construct corresponding to attitudes towards Physics and career aspirations were incorporated into the questionnaire. Likewise, a measure of Relevance of Physics, Reasons to choose to study Physics and Awareness of the GRAO telescope / Development in Africa with Radio Astronomy (DARA) Project in Ghana. Literature on the above instruments can be found in section 3.7.1.1 (Dewitt et al., 2011; 2013). The questionnaire has been provided in appendix 1. The questionnaires for both DARA and Non-DARA students were the same in order to allow for data comparison.

The researcher decided to use surveys for students because they are useful in producing data that can be processed by the use of statistics and are valuable in the identification of relationships between variables and in the creation of generalizations based on the findings of the survey (Cohen et al., 2007). In addition, the focus is on students and the questionnaire for the students will give a better or rich data.

3.7.1.1 Description of Questionnaires

Attitudes Towards Physics Scale (ATPS)-This scale was designed/constructed by the researcher using a Likert scale of five points. This was developed based on existing instruments (Kaur & Zhao, 2017) and with the help of my supervisors. The study explored the attitudes of DARA and Non-DARA students towards Physics in Ghana. A comparison between attitudes of DARA and Non-DARA students towards Physics was made. The ATPS on the questionnaire for the students was made up of 11 items. This scale was used in answering Research Question (RQ) 1.

Reasons to Choose to Study Physics: This scale was adapted and modified from Ogunde et al., (2017). The scale was originally developed for the area of chemistry, but in this study, it was adapted and modified for the area of Physics. This scale had 10 questions/items and intended to find answers to RQ2.

Relevance of Physics: This scale was adapted and modified from the Institute of Physics Report document (IOP, 2006). The scale was originally developed for the broader area of science, but in this study, it was adapted and modified for the area of Physics. This scale explored answers to RQ3. This scale had 10 items on it.

Career Aspirations in Physics: The scale below was also adapted and modified from Ogunde et al., (2017). The scale was originally developed for the area of chemistry, but in this study, it was adapted and modified for the area of Physics. This scale had six items on it and answers RQ4.

Awareness of the GRAO telescope / Development in Africa with Radio Astronomy (DARA) Project in Ghana: This section was designed by the researcher using a Yes/No/Not Sure response. The items on this scale consists of six questions, which measured students' awareness of the GRAO telescope/DARA project. The purpose of this section was to gather contextual data to elucidate whether students who have been taught by a DARA teacher were aware of DARA and GRAO telescope in general, and whether Non-DARA students were not aware of DARA and GRAO telescope in general. We assumed that this would be the case; however, students may report alternate experiences and we wanted to make sure that this was captured so that we were not making incorrect assumptions. This scale answers RQ5.

A five-point Likert scale was used (Allen & Seaman, 2007). The Likert scale was used because:

1. It is quick and economical to administer and score.
2. It is easily adapted to most attitude measurement situations.
3. It provides direct and reliable assessment of attitudes when scales are well constructed.
4. It lends itself well to item analysis procedures.

In the five-point Likert scale, the respondents responded to a series of questions by indicating whether they:

Strongly Agree

Agree

Undecided

Disagree

Strongly Disagree

The items indicated the extent to which the individuals appreciated the questions or the subject of enquiry. The five-point Likert scale type of questionnaire enables the respondents to indicate the degree of their beliefs about a given statement or object.

Table 3.6: Mapping of the Questionnaires to the RQs

Questionnaire	**RQ1**	**RQ2**	**RQ3**	**RQ4**	**RQ5**
Attitudes towards Physics	×				
Relevance of Physics			×		
Reasons to choose to study Physics		×			
Career aspirations in Physics				×	
Awareness of the GRAO telescope / Development in Africa with Radio Astronomy (DARA) project in Ghana					×

3.8 Interviews

Leavy (2017d) defined interview as ‘’a commonly research genre across disciplines in which conversation is used as a data generation tool.’’ It includes posing questions to research participants to answer in a face-to-face situation or by phone. It offers an opportunity to observe non-verbal behaviour of the research participants. It is also expected to attract high response rate. It has the ability for correcting misunderstanding by respondents.

3.8.1 Semi-Structured Interview

Hesse-Biber and Leavy (2011) recommended triangulation as a commonly used approach when multiple methods or sources are applied to address the same question. One means of increasing the trustworthiness of researcher interpretations. Data was triangulated through multiple sources, including interviews and the use of questionnaires. 21 teachers were interviewed once, after the administration of the questionnaires to the students. The interview questions were semi-structured, consisting of ten questions for both DARA and Non-DARA teachers, which covered the impact of the DARA project on students’ engagement with Physics in Ghana. The questions were constructed/developed personally from the researcher based on existing knowledge about the DARA project, his experience as a Physics Teacher and as a DARA Outreach Team member (PRAGSAC).

The interview instruments were very similar for both DARA and Non-DARA teachers in order to allow for data comparison. Teacher’s interviews covered questions that answered specific research questions (as shown in mapping of interview questions to the research questions in table 3.7). The interviews were audio recorded and transcribed (Archer et al., 2013). A sample of the interview protocol has been provided in Appendix 2. The interviews were intended to last between 20 to 30 minutes.

The researcher used an interview protocol for asking questions and recording responses during qualitative interview. The researcher recorded information from interview by making handwritten notes and by audio recording. Notes were taken during the interview when recording were unsuccessful (Thomas, 2017).

Interviewing the teachers gave an understanding about what was happening in the schools. The interview gave the researcher answers to the RQs to be able to triangulate their responses with the students to get better information of what they said. The interview with teachers were for three reasons firstly, for contextual information, secondly to understand the impact of DARA on DARA-trained teachers in terms of their teaching (RQs 6-8) and thirdly, triangulate what the teachers said about students and what the students self-reported.

Table 3.7: Mapping of Interview questions to RQs

Interview Question	**RQ 6**	**RQ7**	**RQ8**
DARA Teachers			
1. Why did you choose to get involved with the DARA training?		×	
2. How has DARA changed the way you teach?		×	
3. How has DARA impacted on your students towards Physics?		×	
4. Has there been a change in the attitudes of the students you teach towards Physics? If ‘’Yes’’ why and if ‘’No’’ why?	×		
5. How do you inspire your students to engage with Physics learning and to further study Physics in the Senior High Schools / Universities / Colleges of Education / Polytechnics etc?		×	
6. What motivation do you give to your students for the learning of Physics?	×	×	
7. Are your students aware of the telescope in Kuntunse (Ghana Radio Astronomy Observatory, GRAO)? How do you know? If ‘’Yes’’ why and if ‘’No’’ why?		×	

8. How do you use the knowledge gain from the DARA training to help your students study Physics?		×	
9. What are your perceptions about careers that involve Physics?			×
10. What are your perceptions about the relevance of studying Physics?		×	
Non-DARA Teachers			
1. Are you aware of the DARA project in Ghana? If ʹʹYesʹʹ why and if ʹʹNoʹʹ why?		×	
2. If response to question 1 is ʹʹYesʹʹ - What do you think about it? If ʹʹNoʹʹ, what awareness do you know?		×	
3. Would you like to be part of the DARA basic training in astronomy in Ghana? If ʹʹYesʹʹ why and if ʹʹNoʹʹ why?		×	
4. Would you like to be part of the DARA outreach team in Ghana? If ʹʹYesʹʹ why and if ʹʹNoʹʹ why?		×	
5. Has there been a change in the attitudes of the students you teach towards Physics? If ʹʹYesʹʹ why and if ʹʹNoʹʹ why?	×		
6. How do you inspire your students to engage with Physics learning and to further study Physics in the Senior High Schools / Universities / Colleges of Education / Polytechnics etc?		×	
7. What motivation do you give to your students for the learning of Physics?	×	×	
8. Are your students aware of the telescope in Kuntunse (Ghana Radio Astronomy Observatory, GRAO)? If ʹʹYesʹʹ why and if ʹʹNoʹʹ why?		×	
9. What are your perceptions about careers that involve Physics?			×
10. What are your perceptions about the relevance of studying Physics?		×	

3.9 Validity of the Instruments

According to Patton (2005), validity of a research instrument is how well it measures what is intended to measure. Bell (2004) also argued that validity of an instrument is important because it determines whether an item measures or describes what it is intended to measure or describe. To ensure validity, the questionnaire was given to the members of the Physics Education Research Group (PERG) at the University of Leeds for their comments and suggestions. The purpose of this was to assess each item's content validity, accuracy and format.

3.10 Reliability of the Instruments

Leavy (2017) defined reliability as ''the dependability/consistency of results.'' It implies that if the results of a study can be replicated under a similar methodology, then the research instrument of the study can be considered as being reliable. To determine the reliability of the instruments for the study, the reliability of the questionnaire was determined using Cronbach alpha coefficient (α). The results were run on International Business Machines Corporation (IBM) Statistical Product and Service Solutions (SPSS) Statistics to determine their Cronbach alpha coefficient (α). The Cronbach alpha was found to be 0.852 which was very high indicating that the scale was reliable. An Inter-rater reliability of the questionnaire was done by the members of PERG to ensure consistency and dependability of the questionnaire.

3.11 Administration of the Research Instrument / Data Collection Procedure

An introductory letter seeking permission for the researcher from the appropriate authorities was provided by the Supervisor, School of Physics & Astronomy of the University of Leeds. Introductory letters were given to the Head teachers and teachers of the study area. Ethical approval, field work risk assessment form, participant's information for teachers and their students and participants consent form was sent to schools for the study for a period of three-four weeks before the questionnaires were administered to the respondents.

3.12 Data Collection Procedure

The investigation took place when the schools were in session for six weeks, so that all subjects had sufficient time to function smoothly. In addition, to ensure a high rate of return of the questionnaire, the questionnaire was directly administered to the students for the study in their classrooms. Directions were given to facilitate an honest and serious set of answers and to ensure anonymity and confidentiality of the respondents. The respondents were given enough time to respond to all items on the questionnaire adequately.

The primary data was obtained from the fieldwork through questionnaires which were administered to the respondents, between January and March 2020 and through interview of the teachers by the researcher. The primary source was considered because such a source of material is always in its original form and relatively free from editing, alteration or modification.

3.13 Scoring the Items on the Instrument

The responses to the items of the questionnaires/survey were scored using five-point Likert scale depending upon whether the items that were worded positively or negatively. Positive stated items such as the; the relevance of Physics and career aspirations in Physics were coded or scored as follows:

- Strongly Agree (SA) = 1
- Agree (A) = 2
- Undecided (U) = 3
- Disagree (DA) = 4
- Strongly Disagree (SD) = 5

This procedure was reversed for negative statements coded or scored as follows:

- Strongly Agree (SA) = 5
- Agree (A) = 4
- Undecided (U) = 3
- Disagree (DA) = 2
- Strongly Disagree (SD) = 1

3.14 Data Analysis

3.14.1 Quantitative Analysis of Student Responses

All the paper-based responses were manually input into Joint Information Systems Committee (JISC) online survey tool.

The data collected was initially analysed using percentages and descriptive procedures. These methods were considered appropriate for an initial inspection of the data, to gain familiarity with the data and also make the analysis and comparisons of the responses easier. The score of each item was found as a percentage of the total score. Conclusions were made by comparing the percentages of responses.

The questions that appeared to have difference following initial inspection using descriptive statistics (Excel) were statistically tested to see if there was any variations in them. This was done to see if there was a significant difference between the DARA and Non-DARA groups.

Test for normality for each of these questions was done to determine whether they were normally distributed. An example of the test results is shown in table 3.8.

Table 3.8: Q4_1 = Q1 on the survey

Case Processing Summary

		Cases					
		Valid		Missing		Total	
	Schooltype	N	Percent	N	Percent	N	Percent
Q4_1	Non-DARA	292	100.0%	0	0.0%	292	100.0%
	DARA	610	100.0%	0	0.0%	610	100.0%

Descriptives

	Schooltype			Statistic	Std. Error
Q4_1	Non-DARA	Mean		3.0685	.07552
			Lower Bound	2.9199	

		95% Confidence Interval for Mean	Upper Bound	3.2171	
		5% Trimmed Mean		3.0609	
		Median		3.0000	
		Variance		1.665	
		Std. Deviation		1.29050	
		Minimum		1.00	
		Maximum		9.00	
		Range		8.00	
		Interquartile Range		2.00	
		Skewness		.190	.143
		Kurtosis		.181	.284
	DARA	Mean		3.1164	.04802
		95% Confidence Interval for Mean	Lower Bound	3.0221	
			Upper Bound	3.2107	
		5% Trimmed Mean		3.1293	
		Median		3.0000	
		Variance		1.407	
		Std. Deviation		1.18608	
		Minimum		1.00	
		Maximum		5.00	
		Range		4.00	
		Interquartile Range		2.00	
		Skewness		-.226	.099
		Kurtosis		-.892	.198

Tests of Normality

	Schooltype	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Q4_1	Non-DARA	.207	292	.000	.900	292	.000
	DARA	.205	610	.000	.907	610	.000

a. Lilliefors Significance Correction

Table 3.8 presents the results from two well-known tests of normality, namely the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test. The Shapiro-Wilk Test is more appropriate for small sample sizes (< 50 samples), but can also handle sample sizes as large as 2000. For this reason, the researcher used the Shapiro-Wilk test as the numerical means of assessing normality.

If the significance value of the Shapiro-Wilk Test is greater than 0.05, the data is normal. If it is below 0.05, the data significantly deviate from a normal distribution.

From table 3.8 for the test for normality the dependent variable was the "Questions i.e. Q4_1 to Q28_2 (for all the questions)." were not normally distributed. All the questions (data) had a significant value less than 0.05 hence the questions were not normally distributed and deviate from normal distribution.

3.14.2 Descriptive Statistics (using excel) on Students Survey/Questionnaire

The score of each item was found as a percentage of the total score using Excel. Conclusions were then be made by comparing the percentages of responses. Descriptive statistics such as percentages were used to describe the data. Comparisons between DARA and Non-DARA have been made. Descriptive statistics for the percentage responses of both Non-DARA and DARA students was carried out for the DARA versus the Non-DARA schools. Following initial inspection, Kruskal Wallis H-tests were conducted for the questions that appeared to have a significant difference between DARA and Non-DARA schools. Statistical comparisons was made between the DARA and Non-DARA students to see if there was a significant difference with any of the elements of the survey. Quantitative methods were used in the analysis of data. The data collected was edited, encoded and analysed through the help of IBM SPSS Statistics and

Excel. Descriptive statistics such as percentages was used to describe the data. In addition, inferential statistics such as Mann-Whitney U-test, The Kruskal-Wallis H test, Pearson/ Spearman correlation and Fisher's test were also used. The results were presented using Tables and Figures as appropriate.

3.14.3 Mann-Whitney U Test & Kruskal-Wallis H Test Analysis

The quantitative data collected from the participants were subjected to Mann-Whitney U test and Kruskal-Wallis H test and using IBM SPSS Statistics data analysis. Statistical analysis using the Mann-Whitney U test and Kruskal-Wallis H test were conducted to determine whether there were statistical significant difference between DARA and Non-DARA with respect to the various questions that the participants answered.

3.14.4 Mann-Whitney U Test Analysis

This test (non-parametric test) was used to determine the significance of differences between the two groups that is DARA and Non-DARA students and schools with regards to their opinions on how they responded to the questions or the manner in which they responded to the questions asked. This was also used to compare differences between the two groups in the way the students answered the questions. The statistical test was used to compare the two independent groups (DARA and Non-DARA) to determine if there is a significant difference between their distributions. The test was used because the data did not meet the assumptions of normality. Hence, t-test was not used. This test involves ranking the data from both groups, calculating the U statistic, and comparing it to critical values from the Mann-Whitney U distribution. The U statistic is based on the sum of ranks of one group relative to the other. The formula for determining the Mann-Whitney U test is given by:

$$U = n_1 n_2 + \frac{n_2(n_2+1)}{2} - \sum_{i=n_1+1}^{n_2} R_i$$

Where:

U=Mann-Whitney U test

n_1 = Sample size one

n_2= Sample size two

R_i = Rank of the sample size

3.14.5 Kruskal-Wallis H Test Analysis

A Kruskal-Wallis H test is a non-parametric test similar to one-way analysis of variance (ANOVA) that allows a researcher to determine statistically significant differences within groups to understand and explain the lack of significance in the Mann-Whitney U tests (Pallant, 2013). Hence, an extension of the Mann-Whitney U test. Kruskal-Wallis H test was conducted to determine whether there was statistical significant difference between DARA and Non-DARA schools with respect to the various questions that the participants answered and also this test was used to determine the variations within the two groups that is DARA and Non-DARA students and schools. There were a lot of variations within the groups. This was done to compare all the schools to each other to see the way in which the students have answered the questions or if they were quite similar. The Kruskal-Wallis H test allows us to determine if there are significant differences between the medians of the groups under consideration. If the calculated H statistic is greater than the critical value (from statistical tables), we can conclude that there is a significant difference between the two groups. The formula for determining the Kruskal-Wallis H test is given by:

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^{\,2}}{n_i} - 3(N+1)$$

Where,

K = number of groups used for comparison

N = total size of the sample

n_i = i-th group's sample size

R_i = total of the ranks related to i-th group

The test is used when the assumptions for parametric tests such as the t-test or analysis of variance (ANOVA) are not met, such as when the data are not normally distributed or the variances are not equal.

3.14.6 Pearson and Spearman Correlation Coefficients

This test was conducted on the Mann Whitney U test results that were significant in the questions the students answered. This was used to determine the relationship between school type (DARA and Non-DARA) that is the significant difference, direction, strength and the statement on the direction of the questions. The distribution of the data was not normal so a t-test cannot used, but because the school type is dichotomous this test can be used to find the direction.

Pearson r correlation is the most widely used correlation statistic to measure the degree of the relationship between linearly related variables. Pearson r correlation is used to measure the degree of relationship between the two. The point-biserial correlation is conducted with the Pearson correlation formula except that one of the variables is dichotomous. The following formula is used to calculate the Pearson r correlation:

$$r_{xy} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\ \sqrt{n\sum y_i^2 - (\sum y_i)^2}}$$

r_{xy} = Pearson r correlation coefficient between x and y

n = number of observations

x_i = value of x (for ith observation)

y_i = value of y (for ith observation)

Spearman rank correlation is a non-parametric test that is used to measure the degree of association between two variables. The Spearman rank correlation test does not carry any assumptions about the distribution of the data and is the appropriate correlation analysis when the variables are measured on a scale that is at least ordinal.

The following formula is used to calculate the Spearman rank correlation:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)}$$

ρ= Spearman rank correlation

d_i= the difference between the ranks of corresponding variables

n= number of observations

The direction of the effect of the Mann-Whitney U test was difficult to interpret from the IBM SPSS output data. Pearson correlation was appropriately used because of the nature of the data and Spearman correlation coefficients was also used to double check the validity of the results from the Mann-Whitney U test and also to give a better insight into the data such as the direction, strength and the statement on the direction of the questions.

3.14.7 Outliers

A school was determined as an outlier for a given question by looking at the number of D and SD responses as a proportion of respondents. Any schools that were different in that consensus were termed as outliers .

3.14.8 Fisher's Exact Test

This test was used to determine the response rate and to check whether there was significant difference between the proportion of DARA and Non-DARA students that responded/answered the question. Fisher's Exact Test is used to determine whether or not there is a significant association between two categorical variables. It is typically used as an alternative to Chi-square test of independence. It is suitable for small sample sizes or when the expected cell counts are low.

3.15 Qualitative Analysis of Students Open Ended Questions (Questionnaire)

This part of the analysis deals with the student's response to the open-ended questions. The analysis was done with the students open ended questions that were linked to the main questions using the Mann Whitney U test. Each of the students responses were recorded down, inspected and coded into various categories and then later condensed into themes for analysis. The total number of responses and percentages for each category were made. Comparison between the Non-DARA and DARA students were made based on the percentages for the various categories. Some of the student's responses belonged to more than one category. The percentages given in the analysis was the percentage of the total respondents/participants and not the percentage of the total number of responses to the specific question. The bolded statements indicates responses of the students that were deemed to be very interesting and showed significant differences between the two groups that is Non-DARA and DARA students.

3.15.1 Analysis on Students' Response Rate of Open-ended Questions (Questionnaire)

This analysis was done to check the number of students (DARA and Non-DARA) who responded and did not responded to the open ended questions using IBM SPSS Statistics. Fisher's exact test was used to determine the response rate and to check whether there was significant difference between the proportion of DARA and Non-DARA students that responded/answered the question. In the table .00 = number of students (DARA and Non-DARA) who did not responded to the open ended questions and 1.00 = number of students (DARA and Non-DARA) who responded to the open ended questions using IBM SPSS Statistics. The test results are shown in table 4.3, 4.4, 4.5 etc.

Table 3.9: Question 10 (From question 9: My teacher was my main influence in liking Physics, what else influence you?)

Schooltype * answeredQ10 Crosstabulation

Count

		answeredQ10		
		.00	1.00	Total
Schooltype	NON-DARA	22	270	292
	DARA	72	538	610
Total		94	808	902

Table 3.10: Question 10 (From question 9: My teacher was my main influence in liking Physics, what else influence you?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
Non-DARA	22	**270**	292	**92.5**
DARA	72	**538**	610	**88.2**
Total	94	808	902	180.7

From table 3.10, it shows that 270 (92.5%) of Non-DARA students and 538 (88.2%) of DARA students responded to the question above which gave a significance of 0.01 and this shows that there was a significance difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Explanation/Meaning of the Various Codes that were deduced from the Data for the Open Ended Questionnaire Questions

1. Knowledge based (positive) - responses of students that mention facts, information and acquisition of skills and were worded positively e.g. knowing/learning Physics well, acquire knowledge, get understanding etc.

2. Knowledge based (negative) - responses of students that mention facts, information and acquisition of skills and were worded negatively e.g. not knowing/learning Physics well, no knowledge acquired, no understanding etc.

3. Long term (positive) goals/benefits – positive responses of students relating to longer term goals/benefits .

4. Long term (negative) goals/benefits - negative responses of students relating to longer term goals/benefits .

5. Short term goals/benefits – positive responses of students relating to shorter term goals/benefits .

6. Desire / Interest (positive) – responses of students desire/interest in Physics that were worded positively e.g. I enjoy, I like, and I'm interested.

7. Desire / Interest (negative) – responses of students desire/interest in Physics that were worded positively e.g. I enjoy, I like, and I'm interested.

8. Resources – materials that are used to facilitate learning of Physics e.g. internet, books etc.

9. People (personal contacts) – responses of students of people that they have personal relationship with e.g. family, brothers, sisters etc.

10. People (professionals) - responses of students of people that they have professional relationship with e.g. doctors, engineers, teachers etc.

11. Nothing/no one/nobody - response by students and these are exactly what they wrote with regards to the questions asked.

12. Nothing/no idea/no reason/can't tell/can't recall – response by students and these are exactly what they wrote with regards to the questions asked.

13. Undecided/not sure – responses given by students that they were not sure and uncertain or were not able to make a decision based on the questions asked.

14. Science careers – responses given by students that were careers in science excluding physicist.

15. Non-science careers - responses given by students that were not careers in science.

16. Practical /Technical careers - responses given by students that were related to careers in practical /technical.

17. Educational careers - responses given by students that were related to careers in education.

18. Physicist - responses given by students that were related to a person whose occupation specializes in the science of Physics at the professional level.

19. Engineering/Engineer - responses given by students that were related to careers in engineering.

20. Medical careers - responses given by students that were related to careers in medical or health care.

21. Advice - responses of students with regards to guidance or recommendations offered by their teachers.

22. I have not been there - responses of students with regards to their knowledge/experience of the GRAO telescope.

23. Correct/right – correct/right responses given by students with regards to what GRAO stands for.

24. Incorrect/wrong – incorrect/wrong responses given by students with regards to what GRAO stands for.

3.16 Qualitative Analysis of Teachers' Interview

The collected interview data were listened to, coded and categorized into themes of the research, based on the research questions. These were Dara and Non-DARA teacher's attitudes towards teaching Physics, perceptions on the relevance of studying Physics, knowledge of career routes in Physics. Teachers were interviewed in their various schools and their responses were recorded by the researcher. Data was analysed using an initial content analysis approach to categorise the responses into themes (Leavy, 2017, p147; Thomas, 2017, p195). Coding and sorting of the data (on key topic areas, themes and by responses to the questions asked) was undertaken by listening carefully to the recordings (Archer et al, 2017; Thomas, 2017, p196) and phrases of interest. The listening of all the recorded interview was done three times to get the teachers responses to the questions correctly categorised into themes. Only significant information from what the teachers' said in the interview were prosed and comparison was made between what the students said to that of the teachers. Any contradictions to what the students said to that of the teachers were recorded. Evidence of what the teachers said was related to that of the student's responses and also the research questions.

3.17 Legend of the Schools on IBM SPSS Statistics in the Data Analysis

Table 3.11: Non-DARA Schools

No.	School
1	Little Shepherd International School
2	Komenda College Practice Basic School
3	Komenda M/A JHS A
4	Komenda M/A JHS B
5	St. Michael & All Angels Anglican JHS
6	Aldersgate Methodist Basic School
7	Entsua Mensah Preparatory/JHS
8	Our Lady of Assumption R/C Basic School

Table 3.12: DARA Schools

No.	School
1	Tiwnikli International SHS
2	Presbyterian Boys' SHS-Legon
3	Kinbu Senior High Technical School
4	Kwabenya Community SHS
5	GAEC Basic School
6	Kuntunse M/A Basic School 1
7	Kuntunse M/A Basic School 2
8	Kuntunse M/A Basic School 3
9	Kuntunse M/A Basic School 4
10	Katapor D/M Basic School
11	Gbawe Islamic Basic School
12	Unity Baptist Academy
13	Jeremite International School

Table 3.13: Legend of Questions on the Questionnaire/IBM SPSS Statistics

Numbering on Questionnaire	**Questions**	**Numbering on IBM SPSS Statistics**
1	Physics is useful in our daily lives.	Q4_1
2	I like Physics better than any subject.	Q4_2
3	Physics should be made optional in our educational curriculum.	Q4_3
4	Physics increases my ability to think logically. Physics helps me to be systematic. Physics helps me to be accurate. Physics helps me to be objective.	Q4_4/Q4_5
5	Physics runs through many other subjects.	Q4_6
6	Physics increases my ability to solve real life problems.	Q4_7
7	I enjoy the challenges presented by Physics problems.	Q4_8
8	I would have stopped studying Physics if it had been optional.	Q4_9
9	My teacher was my main influence in liking Physics.	Q4_10
12	Is it important to study Physics at the SHS?	Q7_1
14	Is it important to study Physics at the Colleges of Education?	Q9_1
16	Is it important to study Physics at the Universities?	Q11_1
19	Physics is relevant to the kind of work that I want to do.	Q14_1
20	Physics is important for the country’s future wealth.	Q14_2
21	Physics helps me to solve problems in life	Q14_3

22	You study Physics because you had no choice / it was compulsory.	Q15_1
23	You study Physics because of the range of jobs available.	Q15_2
24	You study Physics because you are good at it / it's your best subject.	Q15_3
25	You study Physics because you have interest in the subject / enjoy it.	Q15_4
26	Will you choose to study Physics at the SHS?	Q15_5
27	Will you choose to study Physics at the Colleges of Education?	Q15_6
28	Will you choose to study Physics at the Universities?	Q15_7
33	I'm planning a career that uses Physics.	Q20_1
38	Job satisfaction is more important to me than a good salary.	Q25_1
39	Have you been taught the topic ''telescopes'' in class?	Q26_1
40	Are you aware of the DARA project in Ghana?	Q26_2
42	Do you know where the GRAO telescope is located?	Q28_1
43	Have you gone on an excursion to the GRAO telescope?	Q28_2

Chapter 4 : Results and Findings on Students Questionnaire

4.1 Overview

This study was to specifically understand the impact of large-scale radio astronomy projects on student engagement with Physics in Ghana. This chapter presents the data analysis and interpretation of the findings of the students' questionnaire. The chapter presents the demographic data and the analysis according to the research objectives of the students.

4.2 Questionnaire Return Rate

21 schools were approached for this study and questionnaires were administered in all the schools by the researcher. Of the 902 students sampled by the study, all the students filled and returned the questionnaires. These return rates were above 95%; hence, deemed adequate for data analysis as recommended by Mugenda (2003).

4.3 Demographic data of Participants

The demographic information of the students was based on sex, age and school. Data is presented in the following sections:

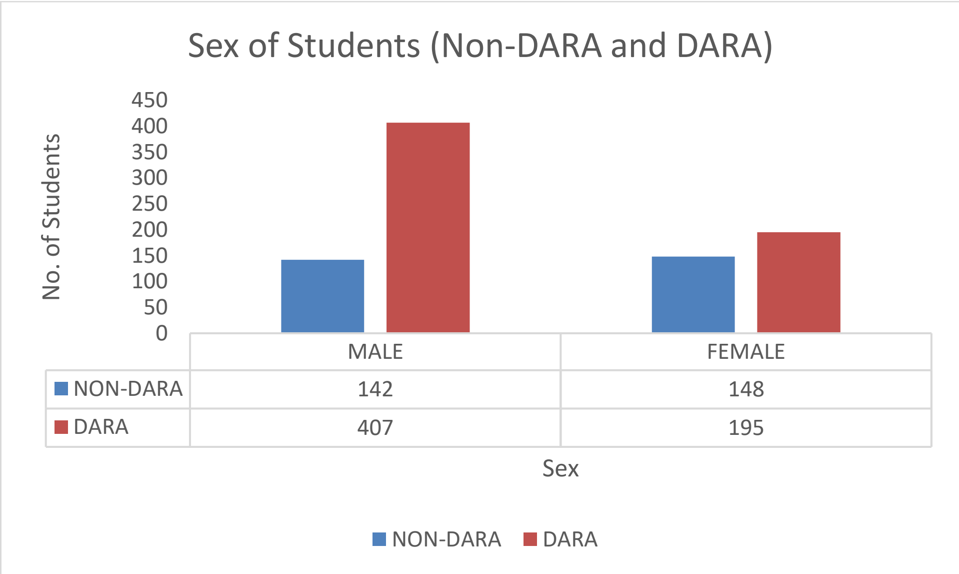


Figure 4.1: Sex of Non-DARA and DARA students

Figure 4.1 indicates that out of the students in the sample, DARA students have higher number of males than the Non-DARA students. This differences may be because one of the DARA schools (Presbyterian Boys SHS) is predominantly a male school.

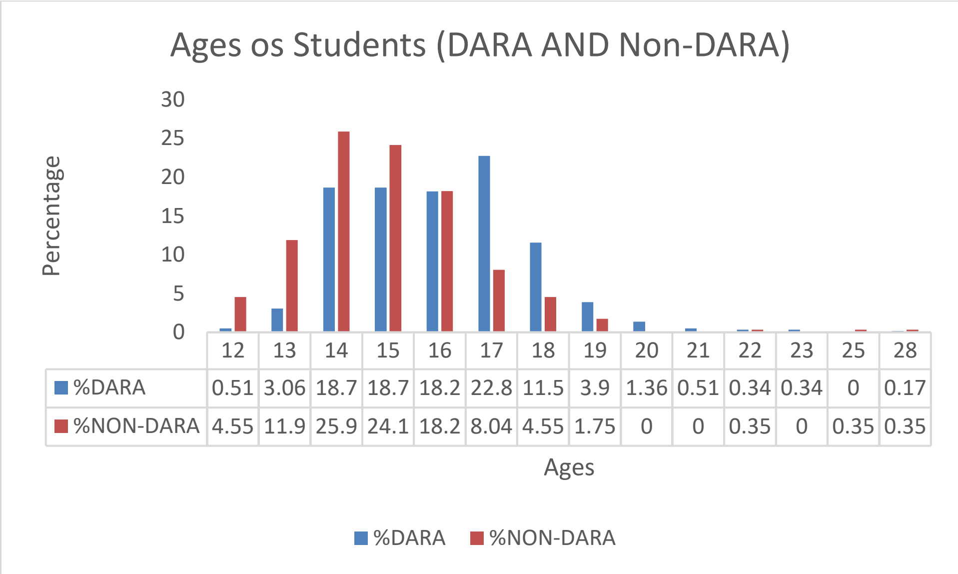


Figure 4.2: Ages of Non-DARA and DARA students

Figure 4.2 shows that there is a wide age range of both DARA and Non-DARA students. This is due to some student’s poor academic performance (students get repeated when they don’t perform well), dropouts (students dropping out of school and later returning back to school), non-transition (students don’t transit to the next level of education on time), some students don’t start school early due to poverty/financial difficulties. All these factors account for the wide age range.

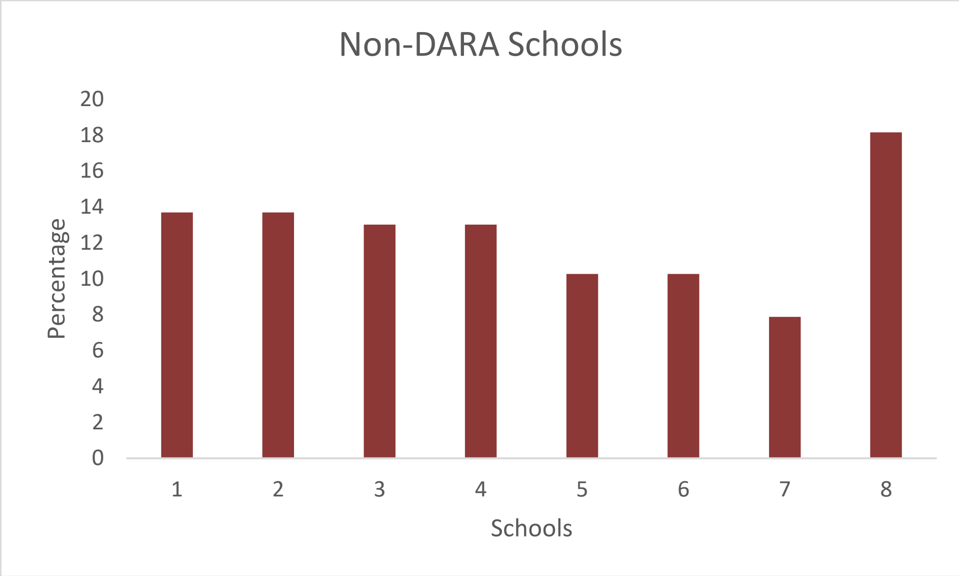


Figure 4.3: Schools of Non-DARA students

Figure 4.3 indicates a graph of the Non-DARA schools and the percentage of the number of students in each school.

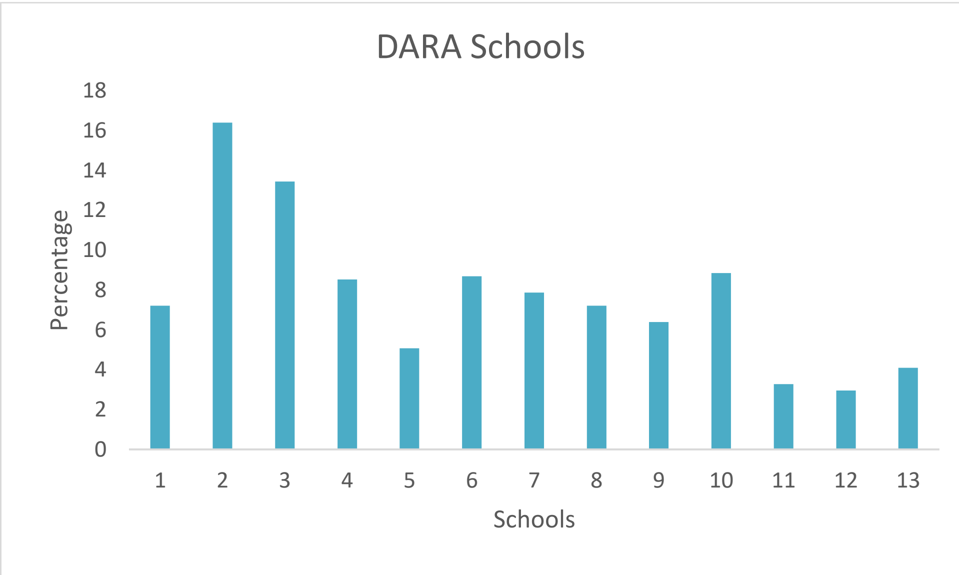


Figure 4.4: Schools of DARA students

Figure 4.4 indicates a graph of the DARA schools and the percentage of the number of students in each school.

4.4 Analysis of the Individual Survey Questions

This section shows the analysis of all the survey questions and the appropriate statistical tests conducted to analyse each of the questions. Interpretation of the results have been described.

Question 1/Q4_1: Physics is useful in our daily lives

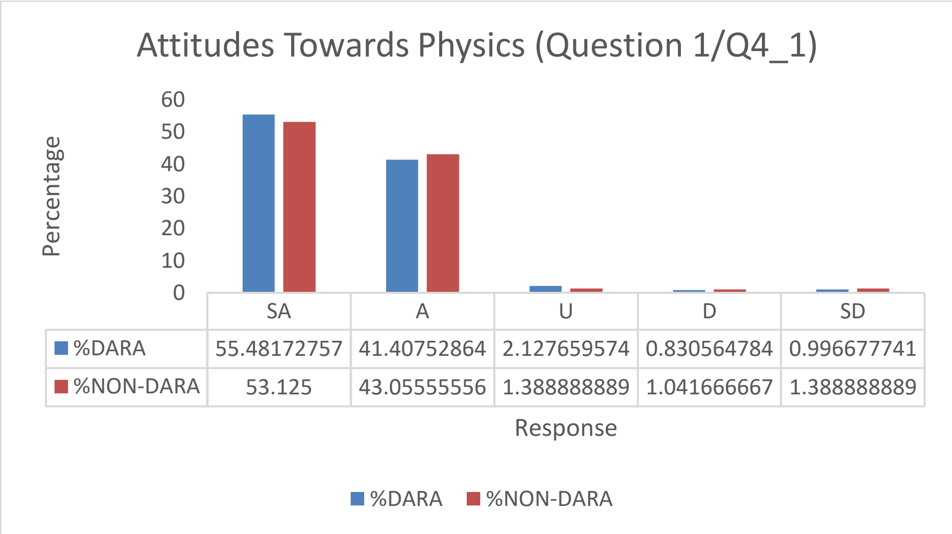


Figure 4.5: Descriptive statistics for question 1/Q4_1

Figure 4.5 shows that 55.5% of DARA students and 53.1% of Non-DARA students strongly agree with the statement, 41.4% of DARA students and 43.1% of Non-DARA students agree with the statement, 2.1% of DARA students and 1.4% of Non-DARA students were undecided with the statement, 0.8% of DARA students and 1.0% of Non-DARA students disagree with the statement, and 1.0% of DARA students and 1.4% of Non-DARA students strongly disagree with the statement ''Physics is useful in our daily lives.'' From the results in Figure 4.5, it appears that there is no significant difference between DARA and Non-DARA students for this question.

Using the Mann-Whitney U test, for question Q4_1 the DARA group (N= 610) had the higher mean rank (455.18) for the statement ''Physics is useful in our daily lives'' than the Non-DARA group (N= 292) with mean rank (443.82). From the test statistics, it can be concluded that there was no statistically significant difference between the DARA group and the Non-DARA group (U =86816.500, p = .528 which is > .05) for the question '' Physics is useful in our daily lives''.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''Physics is useful in our daily lives''. A statistically significant difference was found (H = 25.976, p = .001 which is < .05), indicating that the schools differed from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (171.52) and Aldersgate Methodist Basic School (N=30) had the lowest mean rank (102.18). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ''Physics is useful in our daily lives'' more than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Physics is useful in our daily lives''. A statistically significant difference was found (H = 49.941, p = .000 which is < .05) indicating that the schools differed from each other. The Ghana Atomic Energy Commission Basic School (N=31) had the highest mean rank (396.97) and Gbawe Islamic Basic School (N=20) had the lowest mean rank (169.00). This shows that Ghana Atomic Energy Commission Basic School disagrees more to the statement ''Physics is useful in our daily lives'' more than the other schools and Gbawe Islamic Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q4_1 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 49.941 > $H_{Non\text{-}DARA}$ = 25.976); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

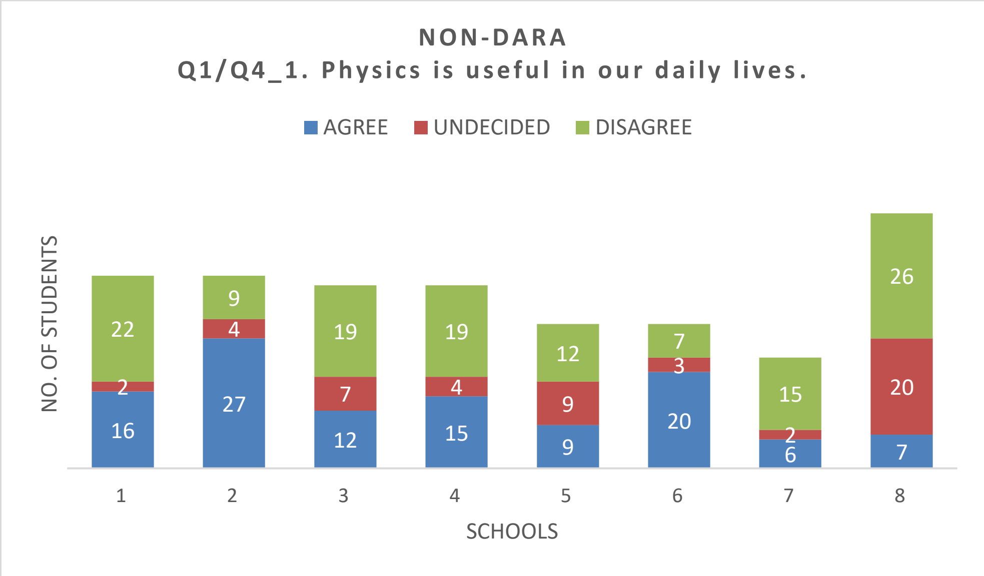


Figure 4.6: Comparison between Non-DARA schools for question 1/Q4_1

From Figure 4.6, it shows that Komenda College Practice Basic School (2) agreed more than any other schools for the Non-DARA schools. Our Lady of Assumption R/C Basic School (8) was an outlier which disagreed more. The significant difference was probably coming from Our Lady of Assumption R/C Basic School (8) more than it was coming from Komenda College Practice Basic School (2) because it was an outlier.

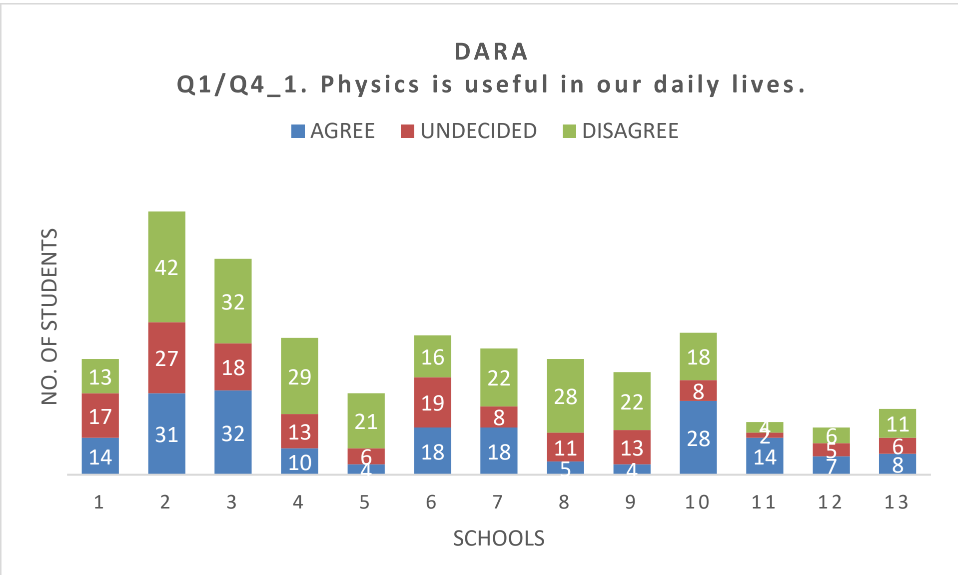


Figure 4.7: Comparison between DARA schools for question 1/Q4_1

From figure 4.7, it shows that all the schools agreed to the statement but Gbawe Islamic Basic School (11) and Katapor D/M Basic School (10) agreed more. Gbawe Islamic Basic School agreed considerably more than Katapor D/M Basic School. Kwabenya Community SHS (4), GAEC Basic School (5), Kuntunse M/A Basic School 3 (8) and Kuntunse M/A Basic School 4 (9) strongly disagreed to the statement. The spread was evenly distributed.

Question 2/Q4_2: I like Physics better than any subject

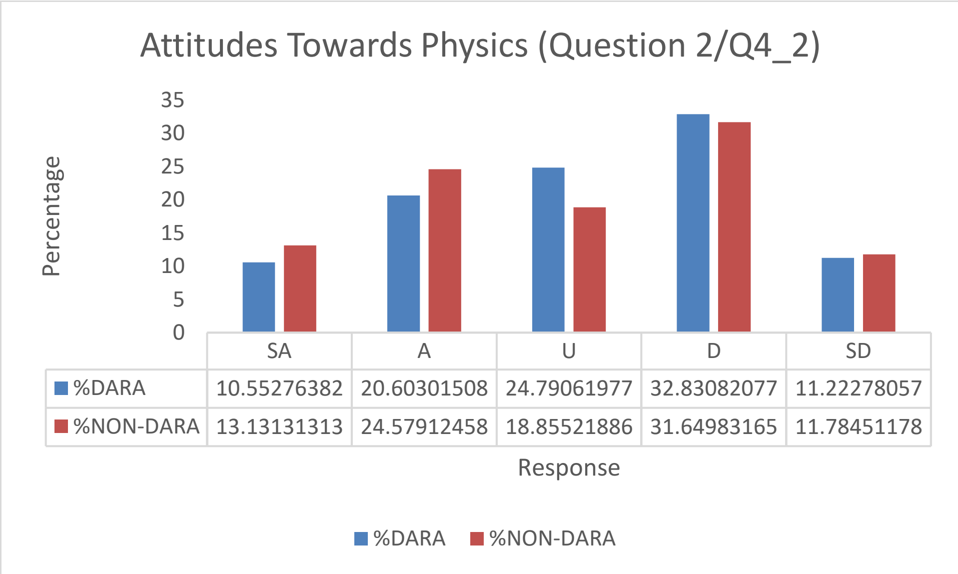


Figure 4.8: Descriptive statistics for question 2/Q4_2

Figure 4.8 shows that, on average, Non-DARA students like Physics better than any other subject more than the DARA students.

Using the Mann-Whitney U test for question Q4_2, the Non-DARA group (N= 292) had the higher mean rank (455.13) for the statement ''I like Physics better than any subject'' than the DARA group (N= 610) with mean rank (449.76). From the test statistics, it can be concluded that there was no statistically significant difference between the DARA group and the Non-DARA group (U =87999.000, p = .765 which is > .05) for the question ''I like Physics better than any subject''

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''I like Physics better than any subject''. No statistically significant difference was found (H = 10.457, p = .164 which is > .05), indicating that the schools did not differ significantly from each other. The Entsua Mensah Preparatory School (N=23) had the highest mean rank (176.72) and Komenda College Practice Basic School (N=40) had the lowest mean rank (119.78). This shows that Entsua Mensah Preparatory School disagrees to the statement ''I like Physics better than any subject'' more than the other schools and Gbawe Islamic Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''I like Physics better than any subject''. No statistically significant difference was found (H = 17.276, p = .139 which is > .05) indicating that the schools did not differ significantly from each other. The Unity Baptist Academy (N=18) had the highest mean rank (362.61) and Jerremite International School (N=25) had the lowest mean rank (238.74). This shows that Unity Baptist Academy disagrees to the statement ''I like Physics better than any subject'' more than the other schools and Jerremite International School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q4_2 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 17.276 > $H_{Non\text{-}DARA}$ = 10.457); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question. However, as there was no statistically significant difference between or within the groups, no further analysis was undertaken.

Question 3/Q4_3: Physics should be made optional in our educational curriculum

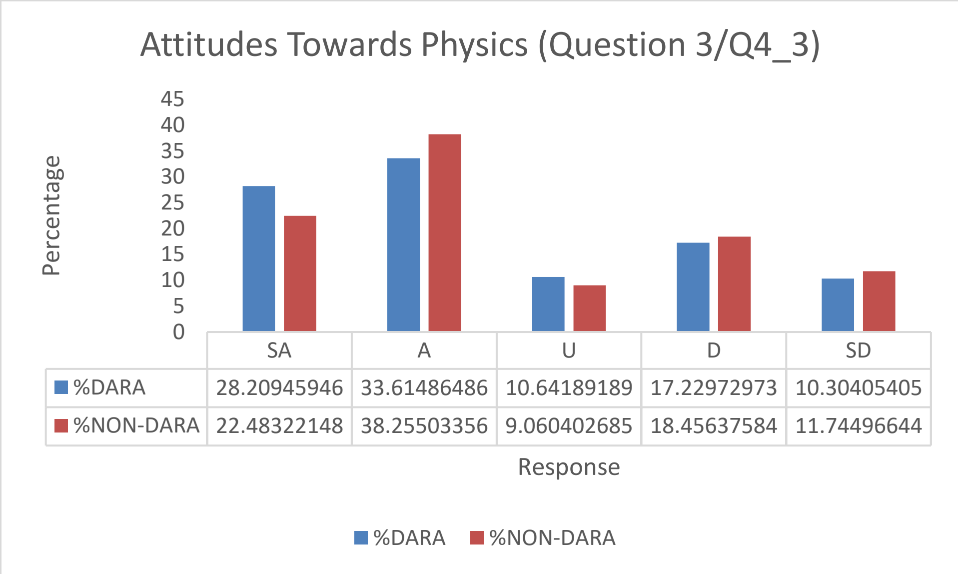


Figure 4.9: Descriptive statistics for question 3/Q4_3

Figure 4.9 shows that majority of Non-DARA students responded to the statement than the DARA students. Overall, more DARA students agreed with the statement.

Using the Mann-Whitney U test for question Q4_3, the Non-DARA group (N= 292) had the higher mean rank (468.06) for the statement ‘’Physics should be made optional in our educational curriculum’’ than the DARA group (N= 610) with mean rank (443.57). From the test statistics, it can be concluded that there was no statistically significant difference between the DARA group and the Non-DARA group (U =84224.500, p = .171 which is > .05) for the question ‘’Physics should be made optional in our educational curriculum’’.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ‘’Physics should be made optional in our educational curriculum’’. No statistically significant difference was found (H = 12.915, p = .074 which is > .05), indicating that the schools did not differ significantly from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (173.51) and Aldersgate Methodist Basic School (N=30) had the lowest mean rank (115.42). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ‘’Physics should be made optional in our educational curriculum’’ more than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Physics should be made optional in our educational curriculum''. A statistically significant difference was found (H = 24.902, p = .015 which is < .05), indicating that the schools did differ significantly from each other. Jerremite International School (N=25) had the highest mean rank (416.62) and Kuntunse M/A Basic School 4 (N=25) had the lowest mean rank (261.06). This shows that Jerremite International School disagrees to the statement ''Physics should be made optional in our educational curriculum'' more than the other schools and Kuntunse M/A Basic School 4 agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q4_3 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 24.902 > $H_{Non\text{-}DARA}$ = 12.915); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

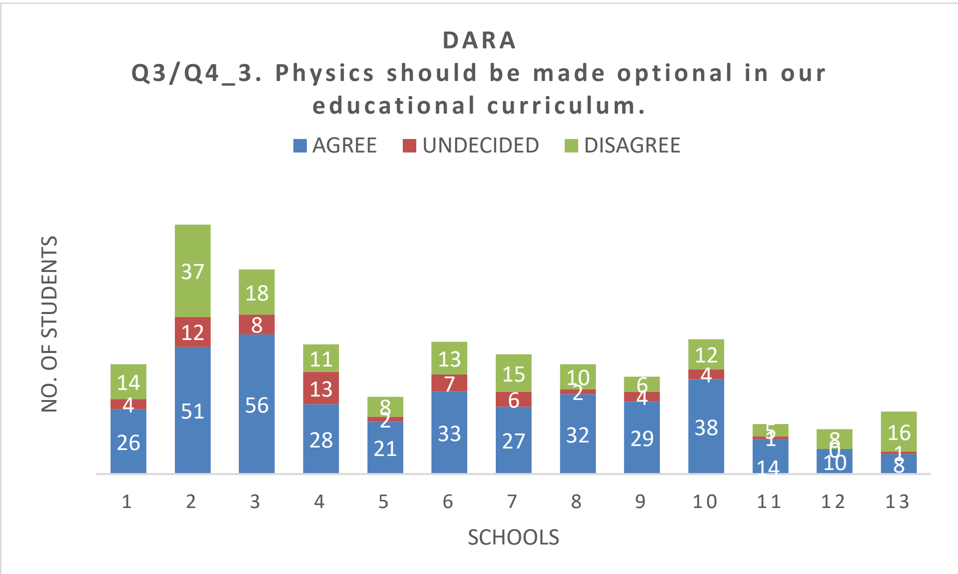


Figure 4.10: Comparison between DARA schools for question 3/Q4_3

From Figure 4.10, it indicates that almost all the schools strongly agreed to the statement but there was an outlier school which was Jeremite International School (13), which agreed lesser than all the other schools and disagreed considerably more than the other schools and so on average, schools agreed to the statement.

Question 4/Q4_5: Physics increases my ability to think logically. Physics helps me to be systematic. Physics helps me to be accurate. Physics helps me to be objective

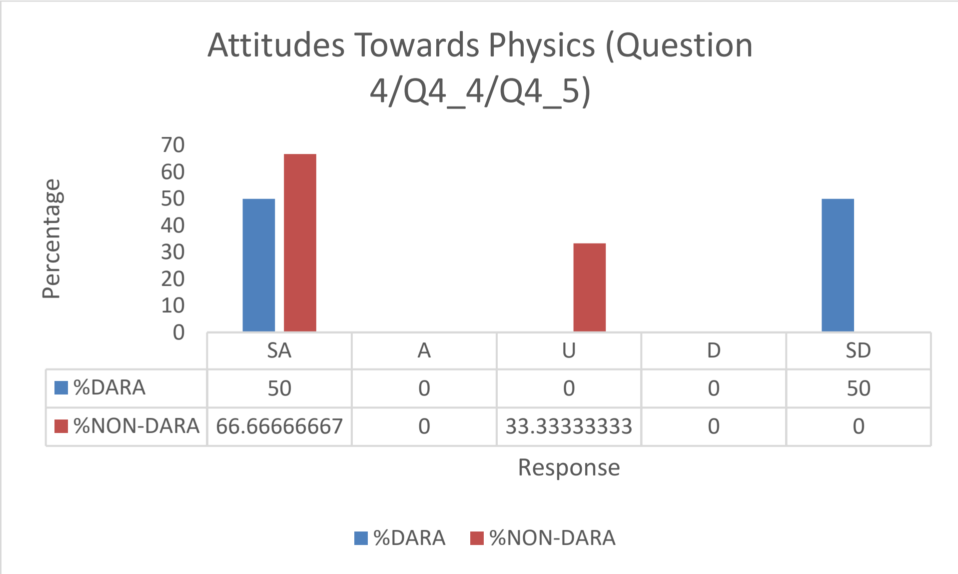


Figure 4.11: Descriptive statistics for question 4/Q4_5

Figure 4.11 shows that Non-DARA agreed more to the statement than the DARA students.

Using the Mann-Whitney U test for question Q4_5, the DARA group (N= 609) had the higher mean rank (461.25) for the statement ''Physics increases my ability to think logically. Physics helps me to be systematic. Physics helps me to be accurate. Physics helps me to be objective'' than the Non-DARA group (N= 291) with mean rank (428.01). From the test statistics, it can be concluded that there was a slightly statistically significant difference between the DARA group and the Non-DARA group (U =82065.500, p = .052 which is < .05). The results indicate that with the Non-DARA group, students believe that Physics increases their ability to think logically, helps them to be systematic, helps them to be accurate and also helps them to be objective more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ‘’Physics increases my ability to think logically, Physics helps me to be systematic, Physics helps me to be accurate, Physics helps me to be objective’’. A statistically significant difference was found (H = 18.267, p = .011 which is < .05), indicating that the schools did differ significantly from each other. Entsua Mensah Preparatory/JHS (N=23) had the highest mean rank (190.28) and Komenda College Practice Basic School (N=40) had the lowest mean rank (120.95). This shows that Entsua Mensah Preparatory/JHS agreed less to the statement ‘’Physics increases my ability to think logically, Physics helps me to be systematic, Physics helps me to be accurate, Physics helps me to be objective’’ than the other schools and Komenda College Practice Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ‘’Physics increases my ability to think logically, Physics helps me to be systematic, Physics helps me to be accurate, Physics helps me to be objective’’. A statistically significant difference was found (H = 41.743, p = .000 which is < .05), indicating that the schools did differ significantly from each other. Ghana Atomic Energy Commission (GAEC) Basic School (N=31) had the highest mean rank (394.45) and Tiwnikli International SHS (N=44) had the lowest mean rank (243.30). This shows that GAEC Basic School agrees less to the statement ‘’Physics increases my ability to think logically, Physics helps me to be systematic, Physics helps me to be accurate, Physics helps me to be objective’’ than the other schools and Tiwnikli International SHS agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q4_5 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 41.743 > $H_{Non\text{-}DARA}$ = 18.267); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type (DARA and Non-DARA) and Q4_5. A weak positive correlation that was not significant was found ($r = .045$, p > .05), indicating there is no significant relationship between the two variables (DARA and Non-DARA). DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (weak), value (.045) and **significant** difference = .176 which is > .05, the p-value) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q4_5. A weak positive correlation that was significant was found *(r = .065, p* < .05), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA to the statement. In conclusion, the direction (positive), strength (weak), value (.065) and **significant** difference = .052 which is = .05, the p-value) of the correlation.

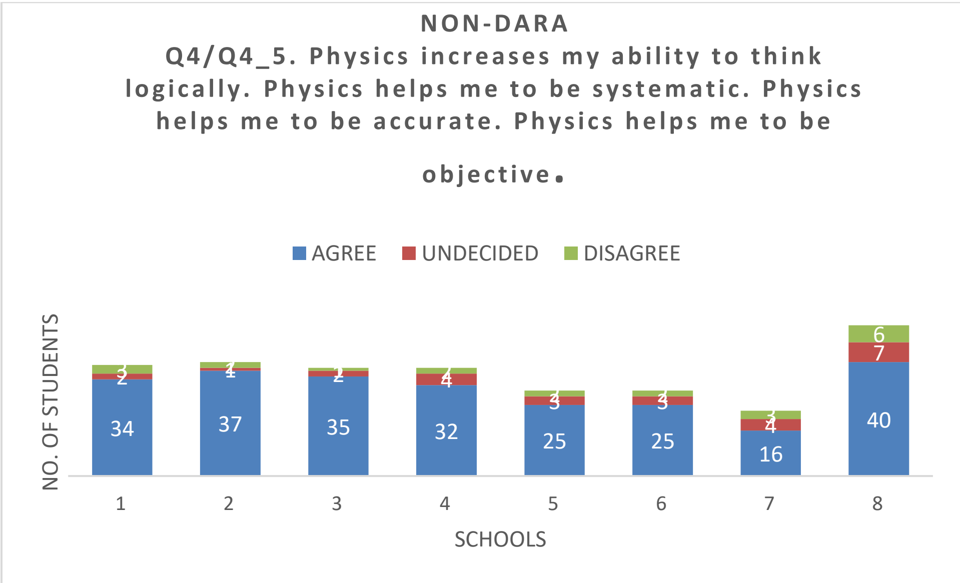


Figure 4.12: Comparison between Non-DARA schools for question 4/Q4_5

From Figure 4.12, it indicates that generally, all the schools strongly agreed to the statement on consensus but the outlier schools were Entsua Mensah Preparatory/JHS (7) and Our Lady of Assumption R/C Basic School (8). The significant Kruskal Wallis results was coming from Entsua Mensah Preparatory/JHS which was really the outlier school. Our Lady of Assumption R/C Basic School was an outlier because it agrees more and also disagrees more than any other school which also contributed to the significant Kruskal Wallis results.

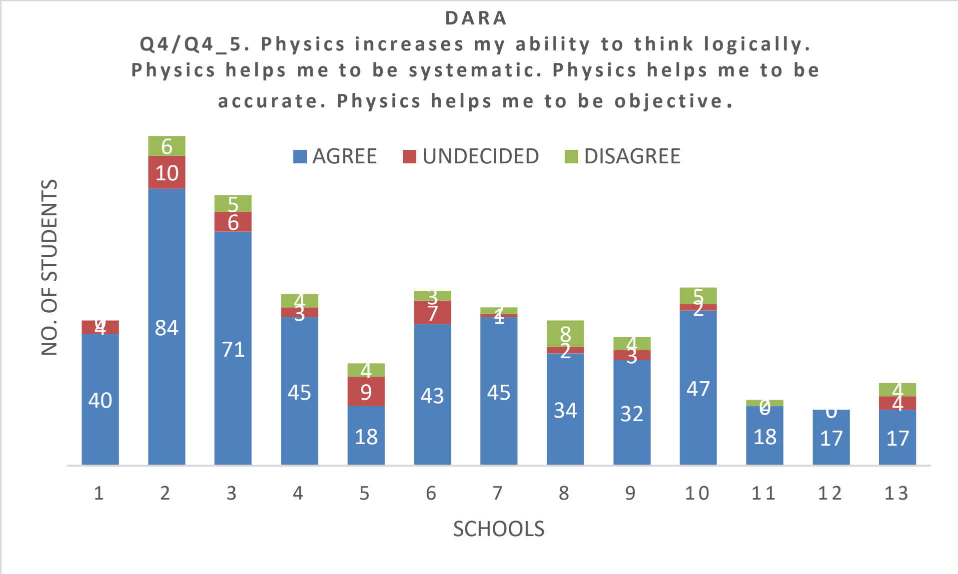


Figure 4.13: Comparison between DARA schools for question 4/Q4_5

From Figure 4.13, it indicates that all the schools agreed to the statement with a little bit of spread/variation. Tiwnikli International SHS (1) and Unity Baptist Academy (12) agreed more than any other school but Unity Baptist Academy strongly agreed more than any other school. A substantial outlier school was GAEC Basic School (5). Tiwnikli International SHS and Unity Baptist Academy were also outliers but in the opposite direction. The majority of the significant Kruskal Wallis results was coming from GAEC Basic School and possibly Jeremite International School.

Question 5/Q4_6: Physics runs through many other subjects

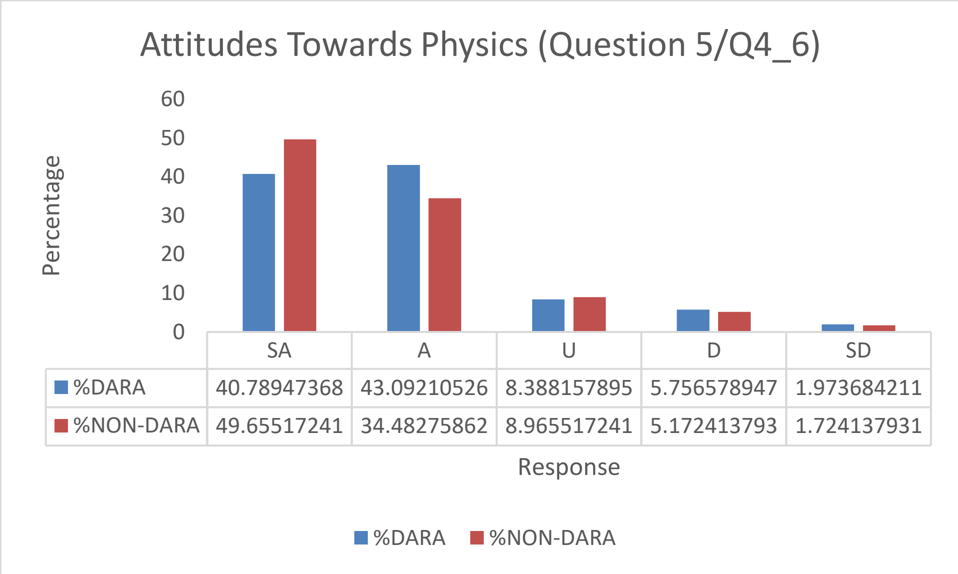


Figure 4.14: Descriptive statistics for question 5/Q4_6

Figure 4.14 shows that Non-DARA students agree more to the statement than the DARA students.

Using the Mann-Whitney U test for question Q4_6, the Non-DARA group (N= 292) had the higher mean rank (472.24) for the statement ''Physics runs through many other subjects'' than the DARA group (N= 610) with mean rank (441.57). From the test statistics, it can be concluded that there was no statistically significant difference between the DARA group and the Non-DARA group (U =83004.000, p = .083 which is > .05) for the question ''Physics runs through many other subjects''.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question statement ''Physics runs through many other subjects''. A statistically significant difference was found (H = 51.672, p = .000 which is < .05), indicating that the schools did differ significantly from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (197.92) and Komenda College Practice Basic School (N=40) had the lowest mean rank (87.39). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ''Physics runs through many other subjects'' more than the other schools and Komenda College Practice Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Physics runs through many other subjects''. A statistically significant difference was found (H = 38.955, p = .000 which is < .05), indicating that the schools did differ significantly from each other. Ghana Atomic Energy Commission (GAEC) Basic School (N=31) had the highest mean rank (412.55) and Kinbu Senior High Technical School (Kinbu SHTS) (N=82) had the lowest mean rank (241.53). This shows that GAEC Basic School disagrees to the statement ''Physics runs through many other subjects'' more than the other schools and Kinbu SHTS agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q4_6 indicates that the Non-DARA schools have a higher Kruskal-Wallis H ($H_{Non\text{-}DARA}$ = 51.672 > H_{DARA} = 38.955); hence, there were more variations within the Non-DARA schools than the DARA schools in terms of how they answered this question.

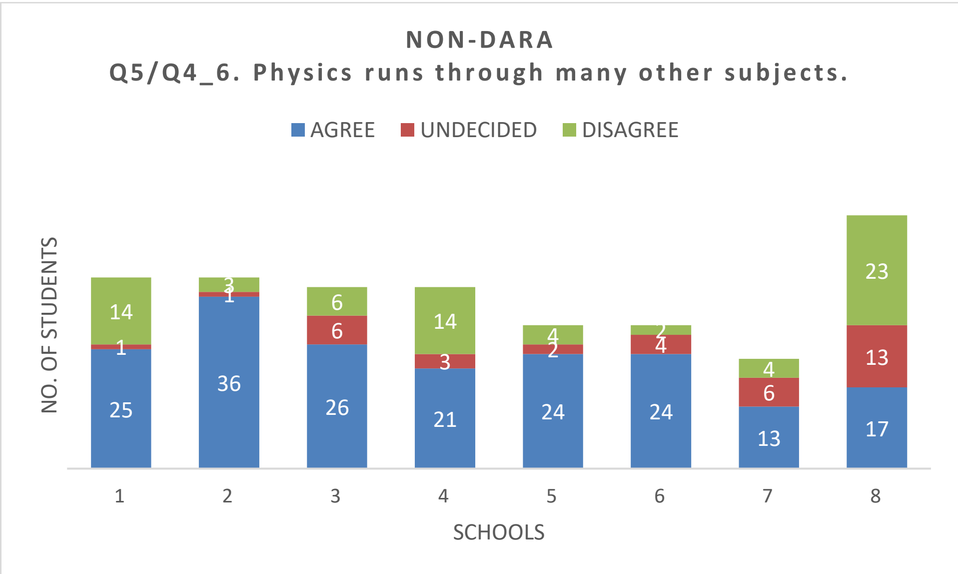


Figure 4.15: Comparison between Non-DARA schools for question 5/Q4_6

From Figure 4.15, it shows that a little bit of a spread was seen. There was consensus in agreeing to the statement. Entsua Mensah Preparatory/JHS (7) and Our Lady of Assumption R/C Basic School (8) were outliers.

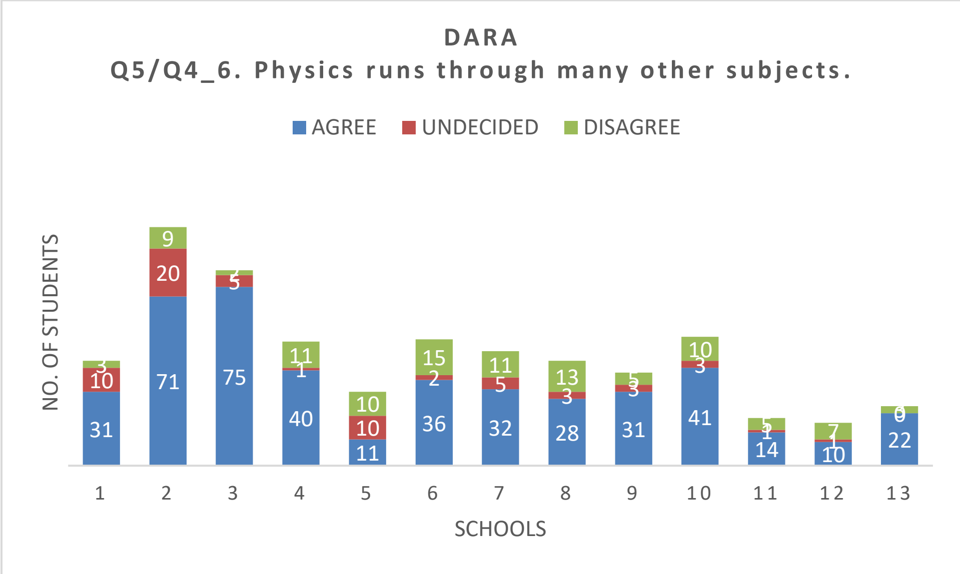
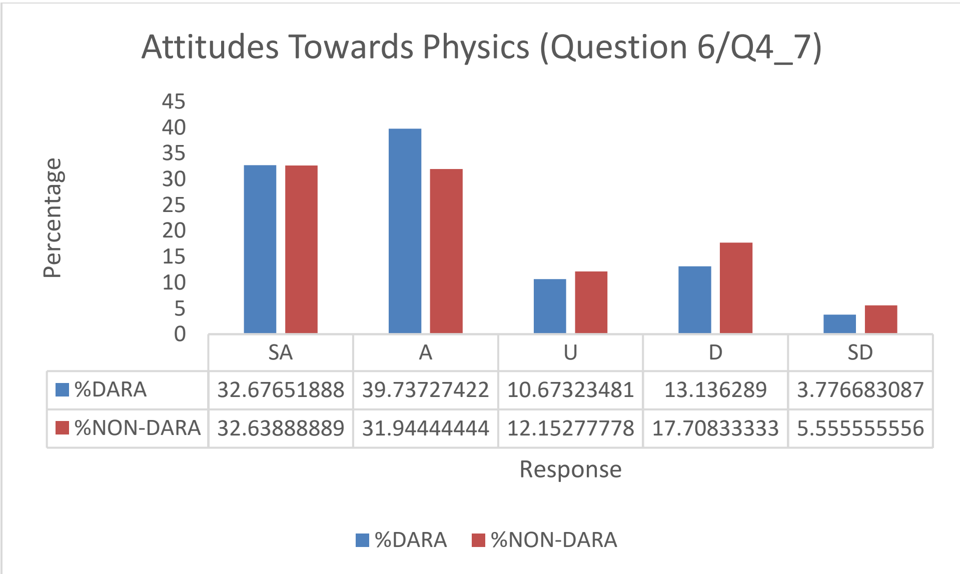


Figure 4.16: Comparison between DARA schools for question 5/Q4_6

From Figure 4.16, it shows that there was a little bit of variation/spread and a significant outlier school (GAEC Basic School; 5) and also there was a bit more spread among Katapor D/M Basic School, Gbawe Islamic Basic School (11), Unity Baptist Academy (12) and Jeremite International School (13).

Question 6/Q4_7: Physics increases my ability to solve real life problems



	SA	A	U	D	SD
%DARA	32.67651888	39.73727422	10.67323481	13.136289	3.776683087
%NON-DARA	32.63888889	31.94444444	12.15277778	17.70833333	5.555555556

Figure 4.17: Descriptive statistics for question 6/Q4_7

Figure 4.17 shows that majority of DARA students responded to the statement more positively than the Non-DARA students. DARA students agree to the statement more than the Non-DARA students.

Using the Mann-Whitney U test for question Q4_7, the DARA group (N= 610) had the higher mean rank (465.41) for the statement ''Physics increases my ability to solve real life problems'' than the Non-DARA group (N= 290) with mean rank (413.16). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =77622.500, p = .003 which is < .05) for the question ''Physics increases my ability to solve real life problems''. The results indicates that with the DARA group, students believe Physics increases their ability to solve real life problems more than the Non-DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''Physics increases my ability to solve real life problems''. A statistically significant difference was found (H = 26.785, p = .000 which is < .05), indicating that the schools did differ significantly from each other. Entsua Mensah Preparatory/JHS (N=22) had the highest mean rank (186.32) and Little Shepherd International School (N=39) had the lowest mean rank (116.51). This shows that Entsua Mensah Preparatory/JHS agrees to the statement ''Physics increases my ability to solve real life problems'' less than the other schools and Little Shepherd International School and Our Lady of Assumption R/C Basic School agreed to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Physics increases my ability to solve real life problems''. No statistically significant difference was found (H = 17.805, p = .122 which is > .05), indicating that the schools did not differ significantly from each other. Jeremite International School (N=25) had the highest mean rank (356.70) and Tiwnikli International SHS (N=43) had the lowest mean rank (259.55). This shows that Jeremite International School agrees less to the statement ''Physics increases my ability to solve real life problems'' than the other schools and Tiwnikli International SHS agrees to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q4_7 indicates that the Non-DARA schools have a higher Kruskal-Wallis H ($H_{Non\text{-}DARA} = 26.875 > H_{DARA} = 17.805$); hence, there were more variations within the Non-DARA schools than the DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q4_7 (Physics increases my ability to solve real life problems). A strong positive correlation was found *(r = .090, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.090) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q4_7. A strong positive correlation was found *(r = .099, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.099) and **significance** level « .01) of the correlation.

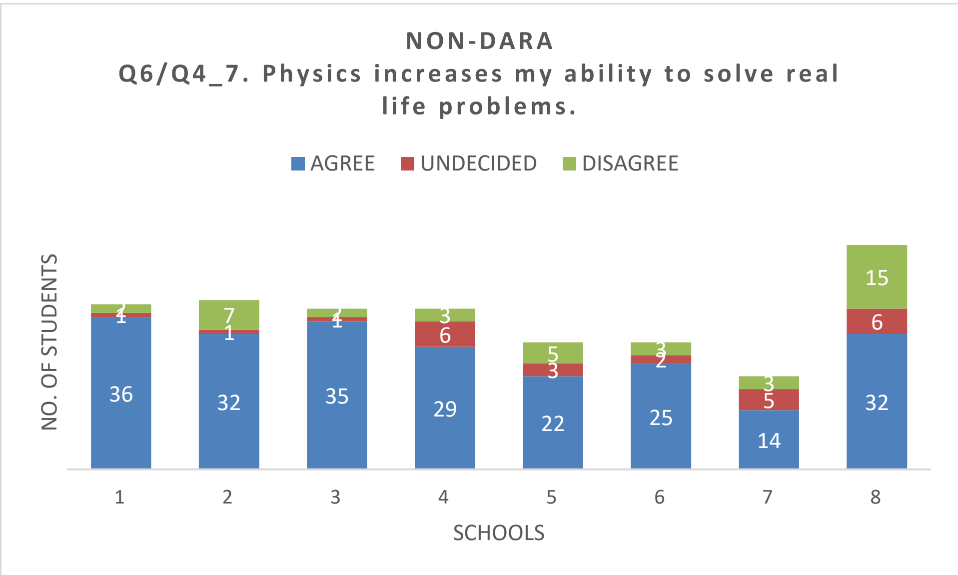


Figure 4.18: Comparison between Non-DARA schools for question 6/Q4_7

From Figure 4.18, it indicates that the spread was not evenly distributed. Our Lady of Assumption R/C Basic School (8) was an outlier school. A fairly consensus to the statement (all schools agree).

Question 7/Q4_8: I enjoy the challenges presented by physics problems

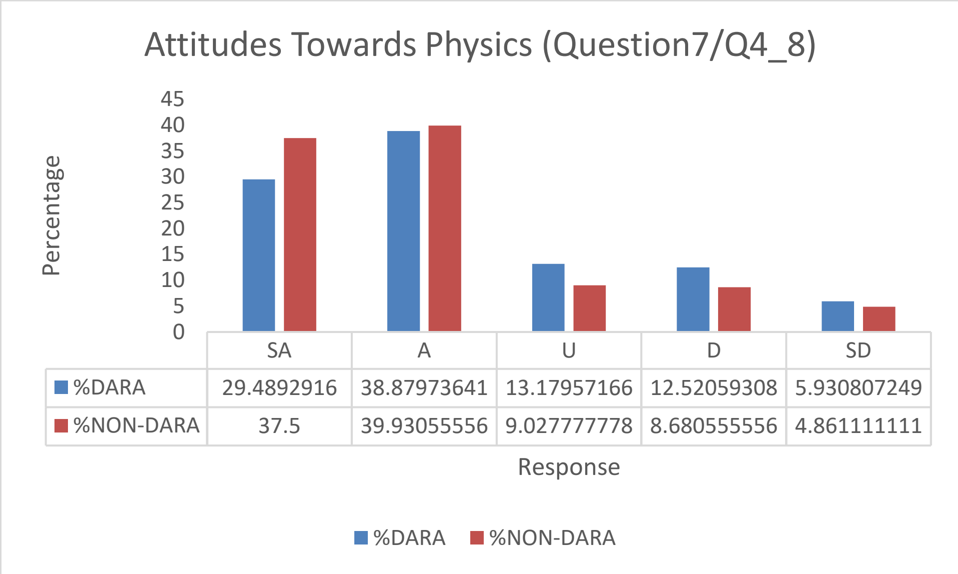


Figure 4.19: Descriptive statistics for question 7/Q4_8

From Figure 4.19, the results shows that majority of Non-DARA students agreed with the statement more than the DARA students.

Using the Mann-Whitney U test for question Q4_8, the DARA group (N= 610) had the higher mean rank (457.48) for the statement ''I enjoy the challenges presented by Physics problems'' than the Non-DARA group (N= 292) with mean rank (439.00). From the test statistics, it can be concluded that there was no statistically significant difference between the DARA group and the Non-DARA group (U =85410.000, p = .306 which is > .05) for the question ''I enjoy the challenges presented by Physics problems''.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''I enjoy the challenges presented by Physics problems''. A statistically significant difference was found (H = 60.425, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (196.00) and Komenda College Practice Basic School (N=40) had the lowest mean rank (96.79). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ''I enjoy the challenges presented by Physics problems'' more than the other schools and Komenda College Practice Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''I enjoy the challenges presented by Physics problems''. A statistically significant difference was found (H = 39.661, p = .000 which is < .05), indicating that the schools differ significantly from each other. Kuntunse M/A Basic School 2 (N=48) had the highest mean rank (373.57) and Gbawe Islamic Basic School (N=20) had the lowest mean rank (212.53). This shows that Kuntunse M/A Basic School 2 disagree more to the statement ''I enjoy the challenges presented by Physics problems'' than the other schools and Gbawe Islamic Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q4_8 indicates that the Non-DARA schools have a higher Kruskal-Wallis H ($H_{Non\text{-}DARA}$ = 60.425 > H_{DARA} = 39.661); hence, there were more variations within the Non-DARA schools than the DARA schools in terms of how they answered this question.

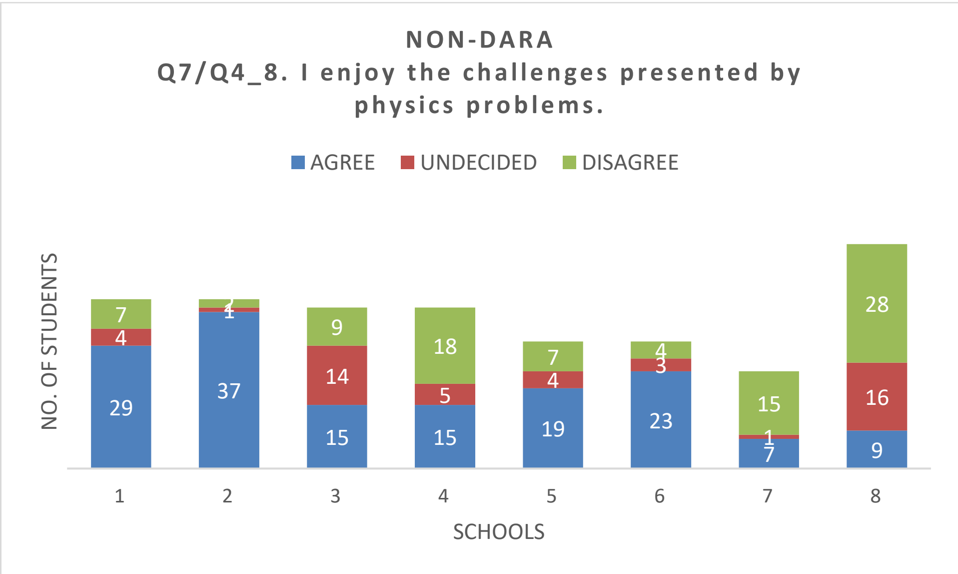


Figure 4.20: Comparison between Non-DARA schools for question 7/Q4_8

Figure 4.20 shows not a fairly general consensus because all the schools had different opinions in responding to the statement. Entsua Mensah Preparatory/JHS (7) strongly disagreed, followed by Our Lady of Assumption R/C Basic School (8). Komenda College Practice Basic School (2) and Our Lady of Assumption R/C Basic School are completely different from each other, hence, more spread within the schools in responding to the statement. No outlier was found because the spread was considerably more.

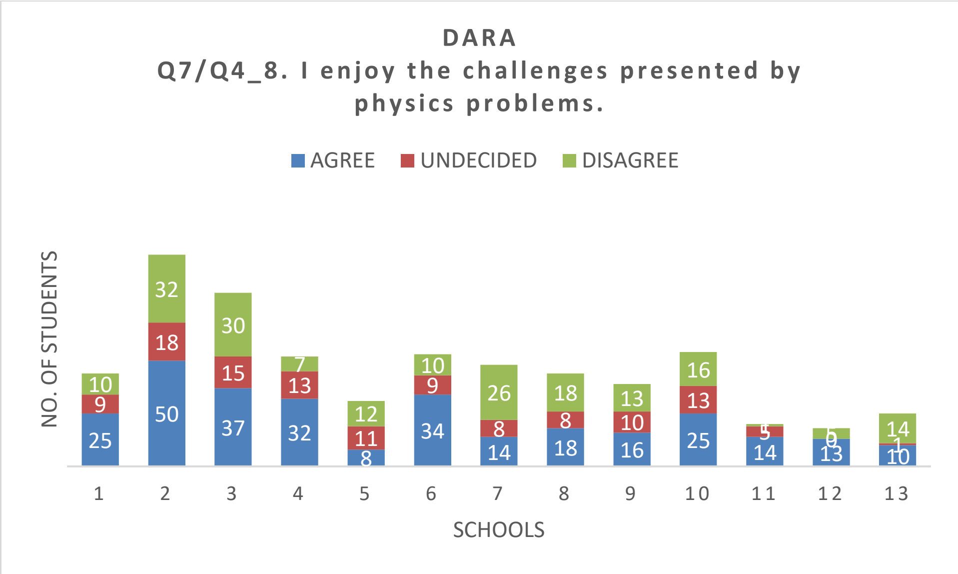


Figure 4.21: Comparison between DARA schools for question 7/Q4_8

Figure 4.21 shows a fairly neutral consensus. GAEC Basic School (5) was the lowest school in terms of agreement to the statement and this was somehow different from the others, in that there were majority disagreeing with the statement.

Question 8/Q4_9: I would have stopped studying Physics if it had been optional

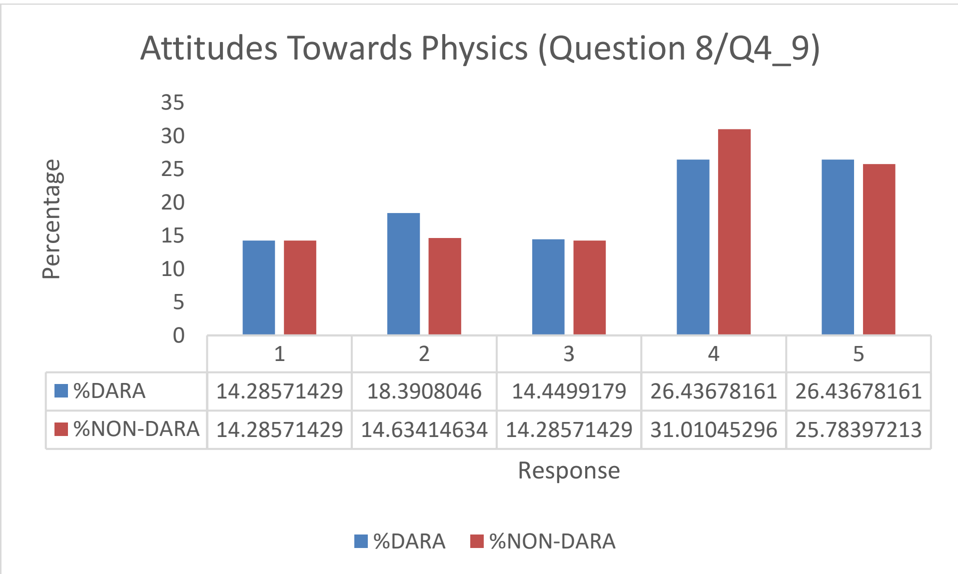


Figure 4.22: Descriptive statistics for question 8/Q4_9

From Figure 4.22, it shows that 14.3% of DARA students and 14.3% of Non-DARA students strongly agree with the statement, 18.4% of DARA students and 14.6% of Non-DARA students agree with the statement, 14.4% of DARA students and 14.3% of Non-DARA students were undecided with the statement, 26.4% of DARA students and 31.0% of Non-DARA students disagree with the statement and 26.4% of DARA students and 25.8% of Non-DARA students strongly disagree with the statement ‘’I would have stopped studying Physics if it had been optional.’’ From the results it shows that more of the Non-DARA students disagreed with the statement more than the DARA students.

Using the Mann-Whitney U test for question Q4_9, the Non-DARA group (N= 292) had the higher mean rank (459.08) for the statement ‘’I would have stopped studying Physics if it had been optional’’ than the DARA group (N= 610) with mean rank (447.87). From the test statistics, it can be concluded that there was no statistically significant difference between the DARA group and the Non-DARA group (U =86848.000, p = .535 which is > .05) for the question ‘’I would have stopped studying Physics if it had been optional’’.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ‘’I would have stopped studying Physics if it had been optional’’. No statistically significant difference was found (H = 8.382, p = .300 which is > .05), indicating that the schools did not differ significantly from each other. Komenda M/A JHS A (N=38) had the highest mean rank (173.61) and Komenda College Practice Basic School (N=40) had the lowest mean rank (131.69). This shows that Komenda M/A JHS A disagrees to the statement ‘’I would have stopped studying Physics if it had been optional’’ more than the other schools and Komenda College Practice Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ‘’I would have stopped studying Physics if it had been optional’’. A statistically significant difference was found (H = 23.941, p = .021 which is < .05), indicating that the schools differ significantly from each other. Tiwnikli International SHS 2 (N=44) had the highest mean rank (351.58) and Kuntunse M/A Basic School 3 (N=44) had the lowest mean rank (227.84). This shows that Tiwnikli International SHS disagrees to the statement ‘’I would have stopped studying Physics if it had been optional’’ more than the other schools and Kuntunse M/A Basic School 3 agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q4_9 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 23.941 > $H_{Non\text{-}DARA}$ = 8.382); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

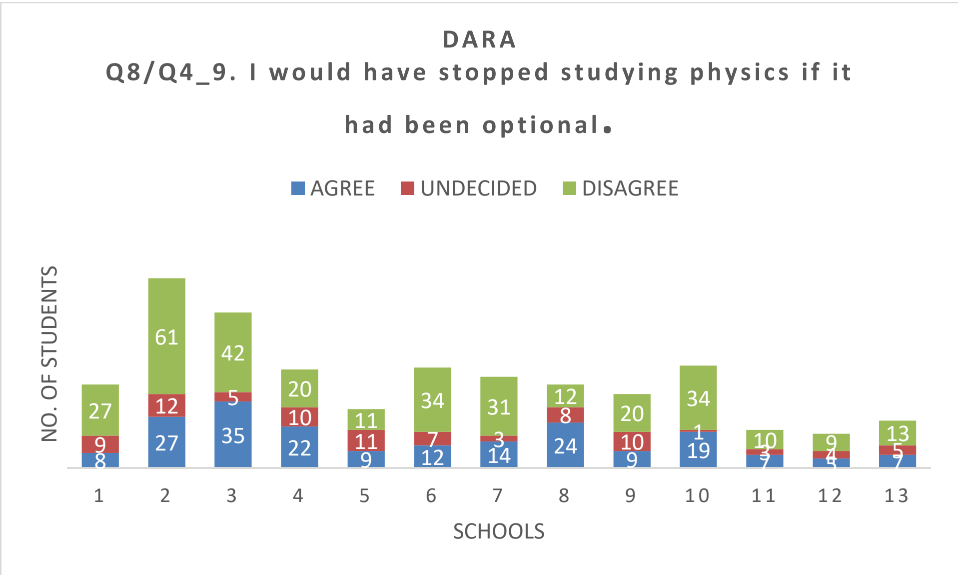


Figure 4.23: Comparison between DARA schools for question 8/Q4_9

From Figure 4.23, it shows that Kuntunse M/A Basic School 3 (8) and Tiwnikli International School were outlier schools. There was reasonably amount of spread among the schools with few schools.

Question 9/Q4_10: My teacher was my main influence in liking Physics

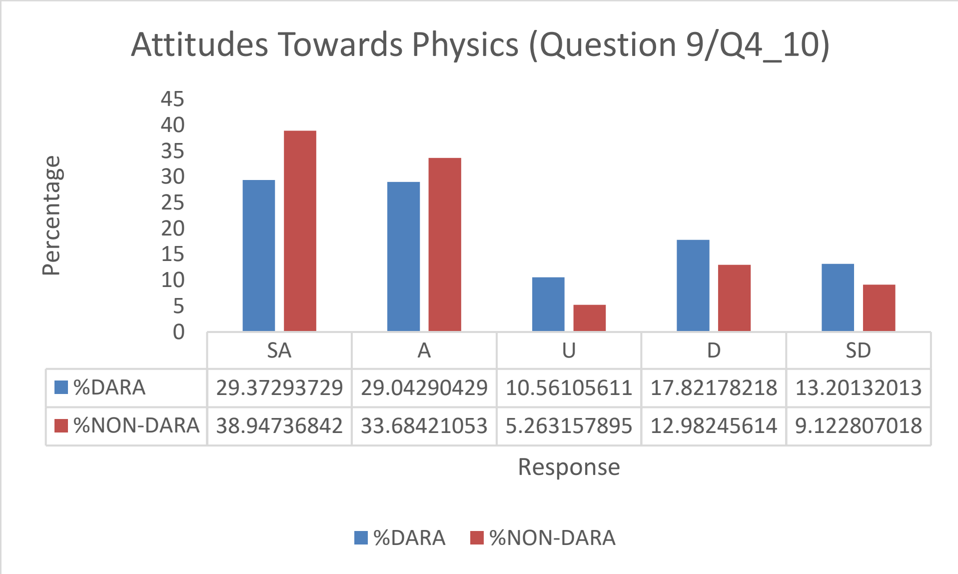


Figure 4.24: Descriptive statistics for question 9/Q4_10

From Figure 4.24, it shows that 29.4% of DARA students and 38.9% of Non-DARA students strongly agree with the statement, 29.0% of DARA students and 33.7% of Non-DARA students agree with the statement, 10.6% of DARA students and 5.3% of Non-DARA students were undecided with the statement, 17.8% of DARA students and 13% of Non-DARA students disagree with the statement and 13.2% of DARA students and 9.1% of Non-DARA students strongly disagree with the statement ‘’My teacher was my main influence in liking Physics.’’ From the results it shows that majority of Non-DARA students agreed with the statement more than the DARA students.

Using the Mann-Whitney U test for question Q4_10, the DARA group (N= 610) had the higher mean rank (470.49) for the statement ‘’my teacher was my main influence in liking Physics’’ than the Non-DARA group (N= 292) with mean rank (411.84). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =77479.000, p = .001 which is < .05) for the question ‘’my teacher was my main influence in liking Physics’’. The results indicate that with the Non-DARA group their teachers were their main influence in liking Physics more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ‘’my teacher was my main influence in liking Physics’’. A statistically significant difference was found (H = 17.106, p = .017 which is < .05) indicating that the schools differ significantly from each other. Entsua Mensah Preparatory/JHS (N=23) had the highest mean rank (170.48) and Aldersgate Methodist Basic School (N=30) had the lowest mean rank (104.78). This shows that Entsua Mensah Preparatory/JHS agrees to the statement ‘’my teacher was my main influence in liking Physics’’ less than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ‘’my teacher was my main influence in liking Physics’’. A statistically significant difference was found (H = 53.647, p = .000 which is < .05), indicating that the schools differ significantly from each other. Presbyterian Boys’ SHS-Legon (N=100) had the highest mean rank (369.30) and Kuntunse M/A Basic School 2 (N=48) had the lowest mean rank (233.69). This shows that Presbyterian Boys’ SHS-Legon disagrees to the statement ‘’my teacher was my main influence in liking Physics’’ more than the other schools and Kuntunse M/A Basic School 2 agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q4_10 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 53.647 > $H_{Non\text{-}DARA}$ = 17.106); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q4_10 (My teacher was my main influence in liking Physics). A strong positive correlation was found *(r = .081, p* < .05), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion the direction (positive), strength (strong), value (.081) and **significance** level « .05) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q4_10. A strong positive correlation was found *(r = .109, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion the direction (positive), strength (strong), value (.109) and **significance** level « .01) of the correlation.

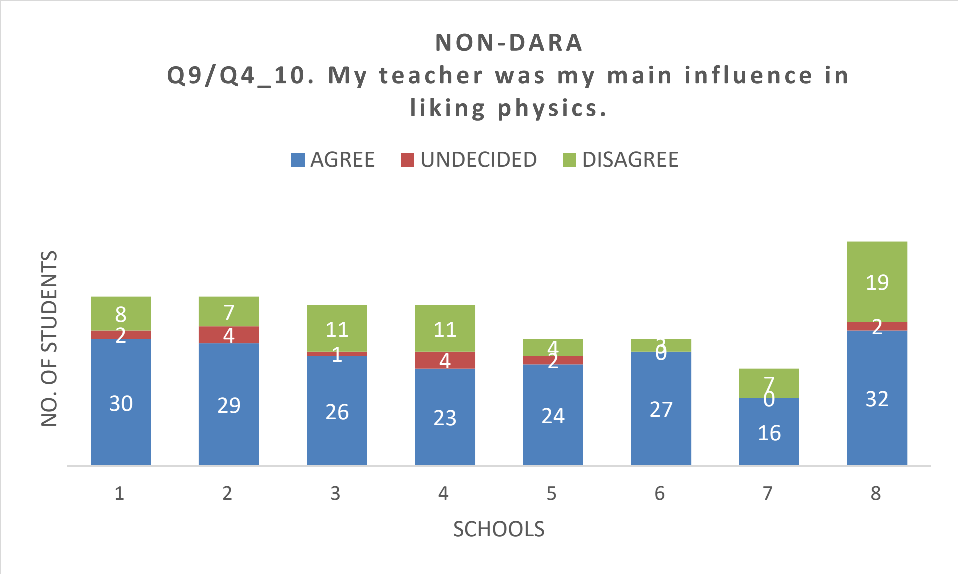


Figure 4.25: Comparison between Non-DARA schools for question 9/Q4_10

Figure 4.25 shows quite an even spread between the schools. Aldersgate Methodist Basic School agreed most.

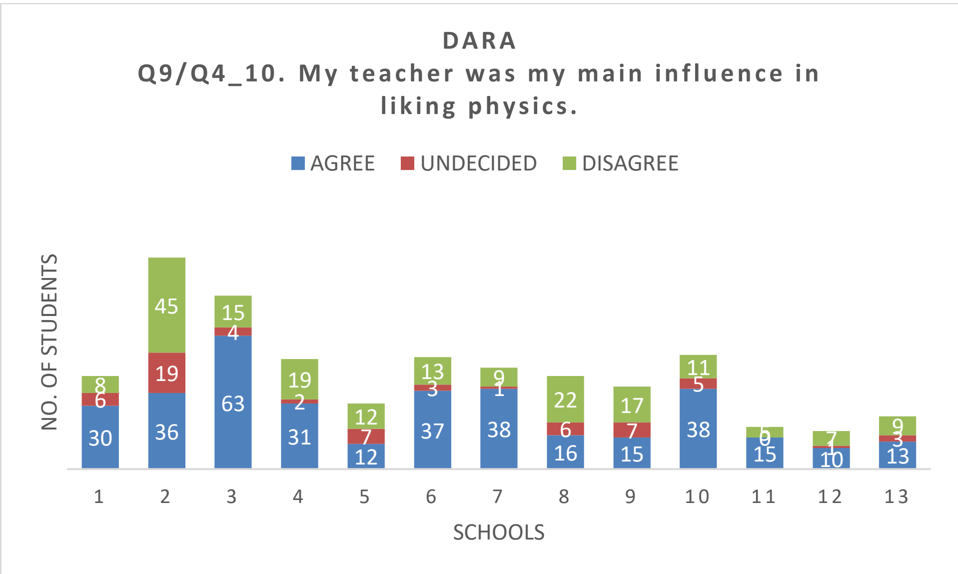


Figure 4.26: Comparison between DARA schools for question 9/Q4_10

Figure 4.26 indicates quite an evenly spread and no outlier in schools. Consensus and disagreement in schools. Presbyterian Boys' SHS-Legon disagree most and Kuntunse M/A Basic School 2 agree most.

Question 12/Q7_1: Is it important to study Physics at the SHS?

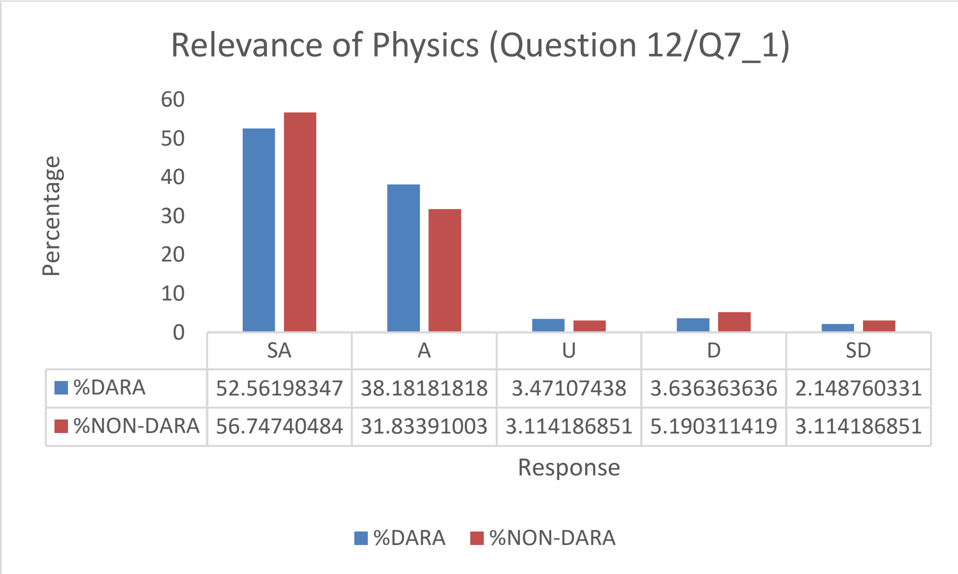


Figure 4.27: Descriptive statistics for question 12/Q7_1

From Figure 4.27, the results shows that majority of Non-DARA students agreed with the statement more than the DARA students. Hence, the Non-DARA students' agree there is high relevance in studying Physics at the SHS.

Using the Mann-Whitney U test for question Q7_1, the DARA group (N= 610) had the higher mean rank (454.80) for the statement ''is it important to study Physics at the SHS?'' than the Non-DARA group (N= 292) with mean rank (444.61). From the test statistics, it can be concluded that there was no statistically significant difference between the DARA group and the Non-DARA group (U =87049.000, p = .540 which is > .05) for the question ''is it important to study Physics at the SHS?''.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''is it important to study Physics at the SHS?''. A statistically significant difference was found (H = 33.318, p = .000 which is < .05), indicating that the schools differ significantly from each other. Little Shepherd

International School (N=40) had the highest mean rank (188.25) and Komenda College Practice Basic School (N=40) had the lowest mean rank (115.58). This shows that Little Shepherd International School agrees less to the statement ''is it important to study Physics at the SHS?'' more than the other schools and Komenda College Practice Basic School agree to the statement than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''is it important to study Physics at the SHS?''. A statistically significant difference was found (H = 30.677, p = .002 which is < .05), indicating that the schools differ significantly from each other. Tiwnikli International SHS (N=44) had the highest mean rank (359.02) and Katapor D/M Basic (N=54) had the lowest mean rank (224.25). This shows that Tiwnikli International SHS agrees to the statement ''is it important to study Physics at the SHS?'' less than the other schools and Katapor D/M Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q7_1 indicates that the Non-DARA schools have a higher Kruskal-Wallis H ($H_{Non\text{-}DARA}$ = 33.318 > H_{DARA} = 30.677); hence, there were more variations within the Non-DARA schools than the DARA schools in terms of how they answered this question.

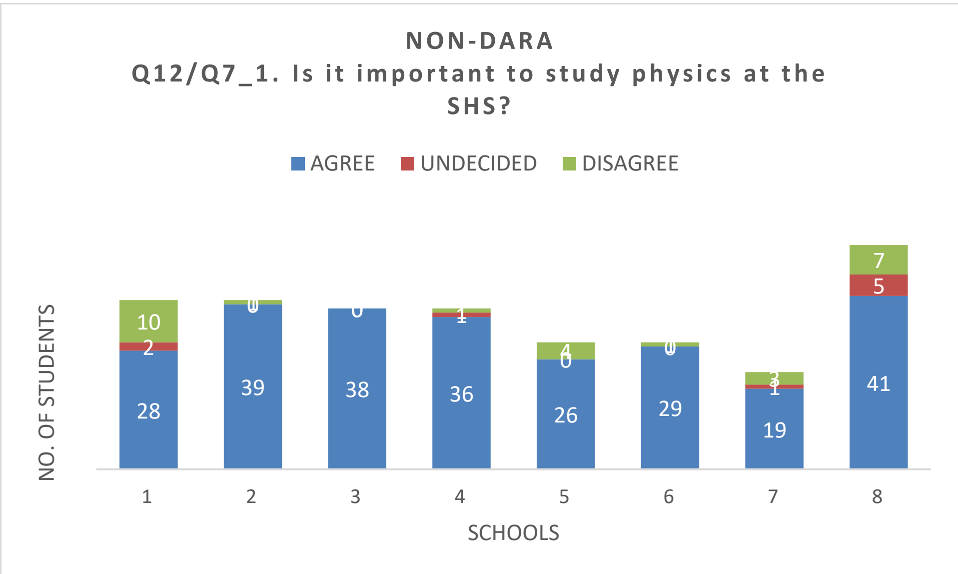


Figure 4.28: Comparison between Non-DARA schools for question 12/Q7_1

Figure 4.28 indicates agreement in schools were very high. Komenda M/A JHS A (3) had no disagreement to the statement and Aldersgate Methodist Basic School (6) also had vast majority of the students agreeing to the statement with the exception of only one student disagreeing to the statement. Same levels of disagreement was found in Komenda College Practice School (2), Komenda M/A JHS B (4) and Aldersgate Methodist Basic School (6). Little Shepherd International School (1) and Our Lady of Assumption R/C Basic School (8) are actually significantly different from the other schools in terms of their responses to the statement because they had more students disagree.

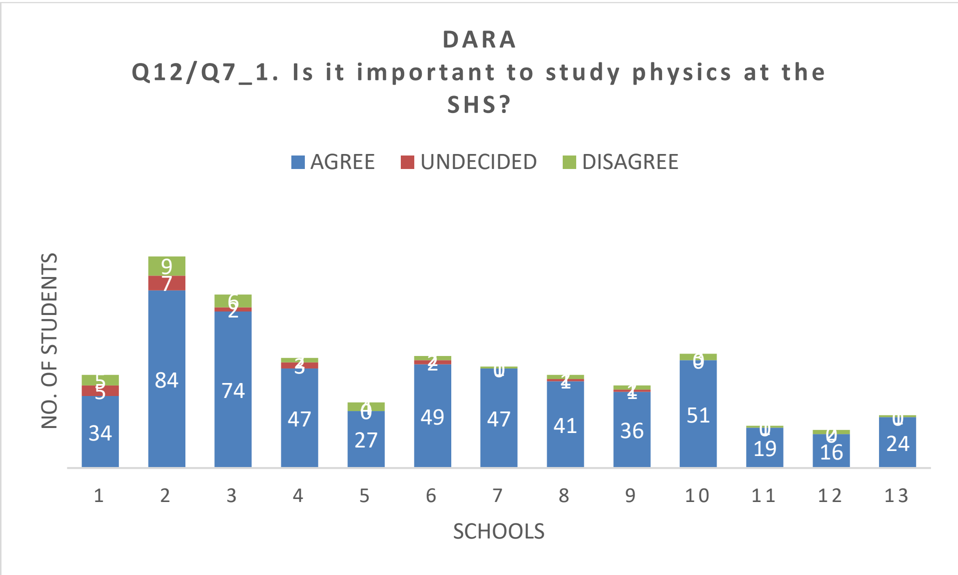


Figure 4.29: Comparison between DARA schools for question 12/Q7_1

From Figure 4.29, it shows that consensus was very high. Twinikli International SHS (1) and Presbyterian Boys' SHS-Legon (2) contributed to the significant results for the Kruskal Wallis test and were significantly different from the other schools in responding to the statement.

Question 14/Q9_1: Is it important to study Physics at the Colleges of Education?

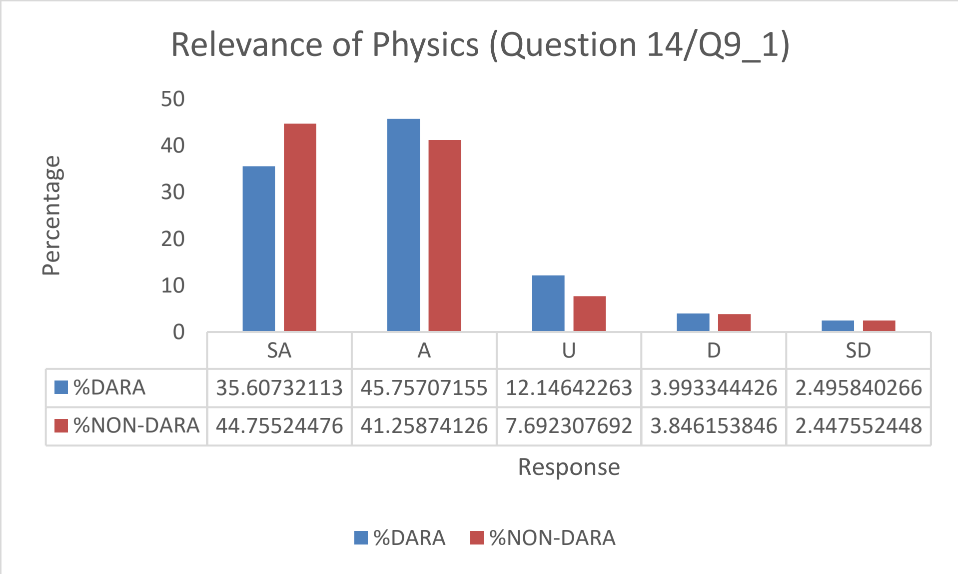


Figure 4.30: Descriptive statistics for question 14/Q9_1

Figure 4.30 shows that majority of Non-DARA students agreed with the statement more than the DARA students. Hence, the Non-DARA students' agree there is high relevance in studying Physics at the CoE.

Using the Mann-Whitney U test for question Q9_1, the DARA group (N= 610) had the higher mean rank (464.81) for the statement ''is it important to study Physics at the Colleges of Education?'' than the Non-DARA group (N= 292) with mean rank (423.69). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =80938.500, p = .017 which is < .05) for the question ''is it important to study Physics at the Colleges of Education?''. The results indicates that with the Non-DARA group it is important to study Physics at the Colleges of Education more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''is it important to study Physics at the Colleges of Education?''. A statistically significant difference was found (H = 18.604, p = .010 which is < .05), indicating that the schools differ significantly from each other. Entsua Mensah Preparatory/JHS (N=23) had the highest mean rank (178.15), and Komenda College Practice Basic School (N=40) had the lowest mean rank (106.15). This shows that Entsua

Mensah Preparatory/JHS disagrees to the statement ''is it important to study Physics at the Colleges of Education?'' than the other schools and Komenda College Practice Basic School agree to the statement than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''is it important to study Physics at the Colleges of Education?''. A statistically significant difference was found (H = 57.675, p = .000 which is < .05), indicating that the schools differ significantly from each other. Tiwnikli International SHS (N=44) had the highest mean rank (380.48), and Katapor D/M Basic (N=54) had the lowest mean rank (220.96). This shows that Tiwnikli International SHS agrees to the statement ''is it important to study Physics at the Colleges of Education?'' less than the other schools, and Katapor D/M Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q9_1 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 57.675 > $H_{Non\text{-}DARA}$ = 18.604); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q9_1 (Is it important to study Physics at the Colleges of Education?). A weak positive correlation that was not significant was found *(r = .042, p* > .05). DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (weak), value (.042) and **significant** difference = .212) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q9_1. A strong positive correlation was found *(r = .080, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.080) and **significance** level « .05) of the correlation.

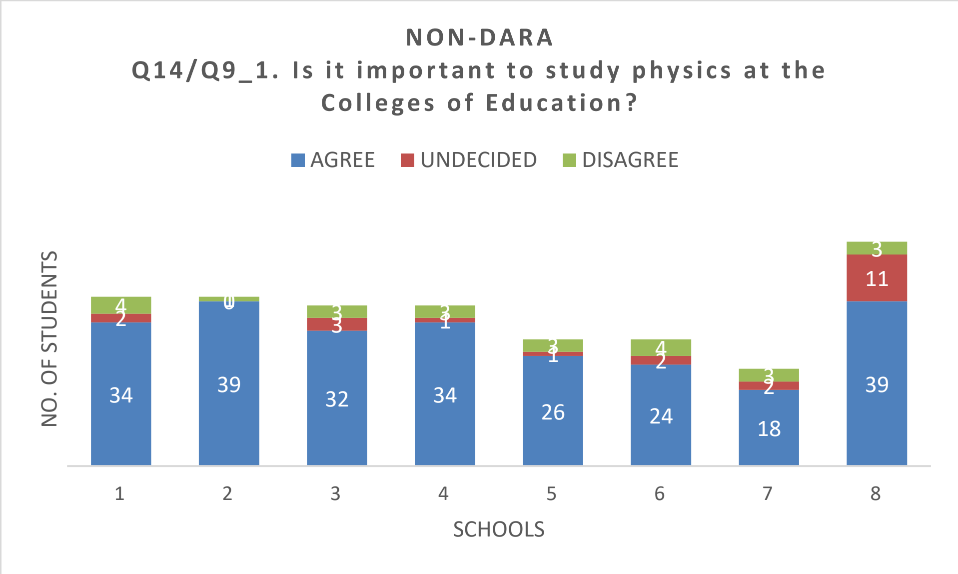


Figure 4.31: Comparison between Non-DARA schools for question 14/Q9_1

Figure 4.31 shows an even spread among the schools. Consensus to the statement, Little Shepherd International School (1), Komenda M/A JHS A (3) and St. Michael & All Angels Anglican JHS (5) had the same level of agreement likewise school Aldersgate Methodist Basic School (6) and Entsua Mensah Preparatory/JHS (7). Also, Komenda College Practice Basic School (2) been the only different one disagreeing lesser to the statement. Komenda M/A JHS A (3) and Komenda M/A JHS B (4) had the same level of disagreement likewise Little Shepherd International School (1) and St. Michael & All Angels Anglican JHS (5). Aldersgate Methodist Basic School (6) and Entsua Mensah Preparatory/JHS (7) both had the same level of agreement and disagreement to the statement.

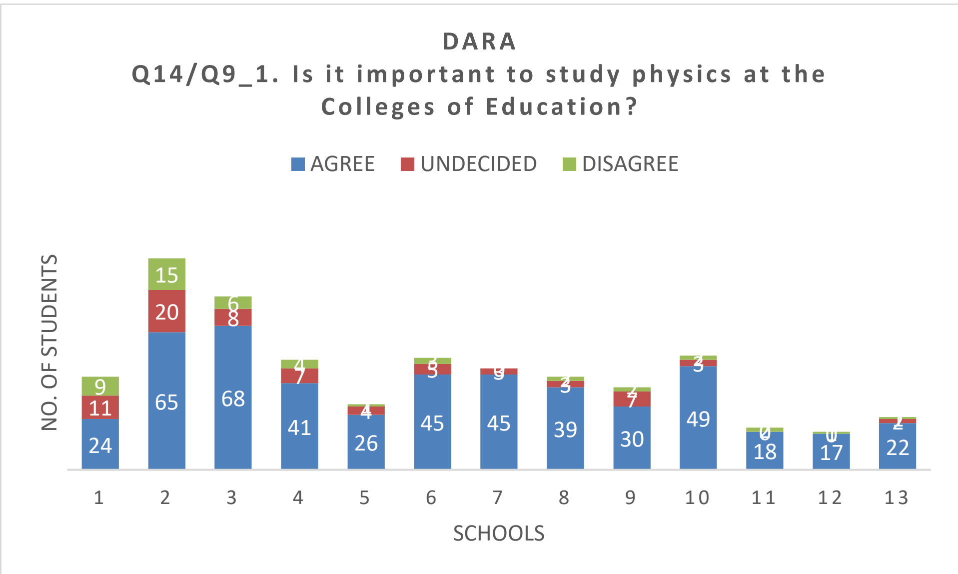


Figure 4.32: Comparison between DARA schools for question 14/Q9_1

Figure 4.32 indicates consensus to the statement between the schools. An even spread in terms of agreement. Little Shepherd International School (1) and Komenda College Practice Basic School (2) were significantly different from the other schools in responding to the statement.

Question 16/Q11_1: Is it important to study Physics at the Universities?

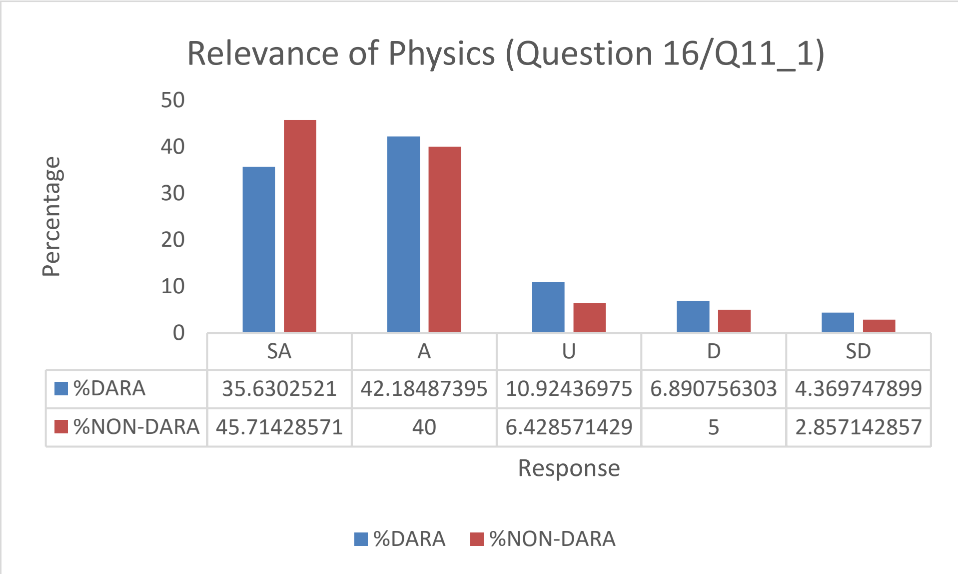


Figure 4.33: Descriptive statistics for question 16/Q11_1

Figure 4.33 shows that 35.6% of DARA students and 45.7% of Non-DARA students strongly agree with the statement, 42.2% of DARA students and 40.0% of Non-DARA students agree with the statement, 10.9% of DARA students and 6.4% of Non-DARA students were undecided with the statement, 6.9% of DARA students and 5.0% of Non-DARA students disagree with the statement and 4.4% of DARA students and 2.9% of Non-DARA students strongly disagree with the statement ‘’Is it important to study Physics at the Universities?’’ From the results it shows that majority of Non-DARA students responded to the statement more than the DARA students. Hence the Non-DARA students’ high relevance in studying Physics at the Universities.

Using the Mann-Whitney U test for question Q11_1, the DARA group (N= 594) had the higher mean rank (455.08) for the statement ‘’is it important to study Physics at the

Universities?'' than the Non-DARA group (N= 281) with mean rank (401.89). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =73311.000, p = .002 which is < .05) for the question ''is it important to study Physics at the Universities?''. The results indicate that with the Non-DARA group it is important to study Physics at the Universities more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''is it important to study Physics at the Universities?''. A statistically significant difference was found (H = 28.616, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (177.84), and Aldersgate Methodist Basic School (N=25) had the lowest mean rank (102.40). This shows that Our Lady of Assumption R/C Basic School agrees to the statement ''is it important to study Physics at the Universities?'' less than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''is it important to study Physics at the Universities?''. A statistically significant difference was found (H = 44.633, p = .000 which is < .05), indicating that the schools differ significantly from each other. Presbyterian Boys' SHS-Legon (N=100) had the highest mean rank (366.84) and Katapor D/M Basic (N=54) had the lowest mean rank (238.39). This shows that Presbyterian Boys' SHS-Legon disagrees to the statement ''is it important to study Physics at the Universities?'' more than the other schools and Katapor D/M Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q11_1 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 44.633 > $H_{Non\text{-}DARA}$ = 28.616); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q11_1 (Is it important to study Physics at the Universities?). A strong positive correlation was found *($r = .095$, $p < .01$)*, indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.095) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q11_1. A strong positive correlation was found *($r = .105$, $p < .01$)*, indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.105) and **significance** level « .01) of the correlation.

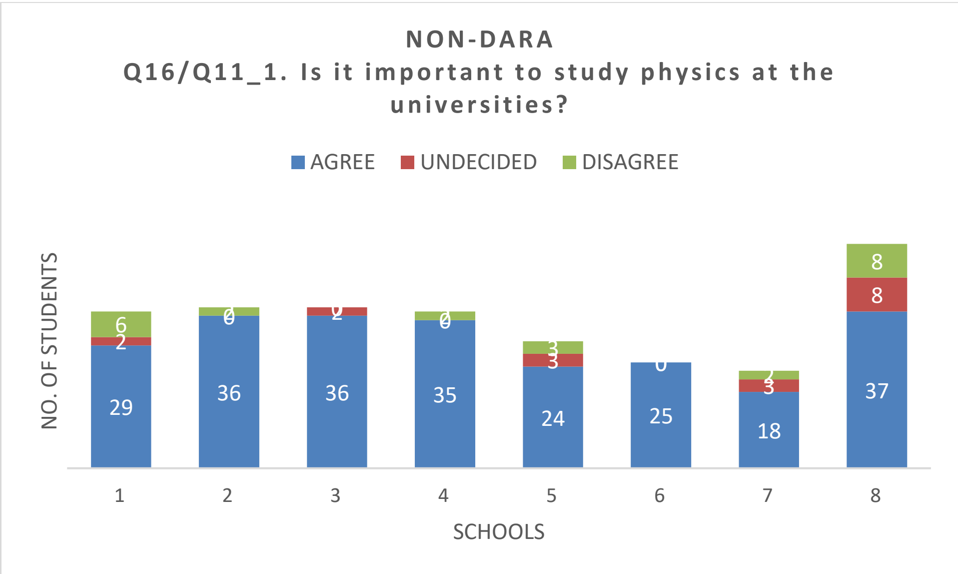


Figure 4.34: Comparison between Non-DARA schools for question 16/Q11_1

Figure 4.34 shows consensus and an evenly spread among the schools. Our Lady of Assumption R/C Basic School (8) was an outlier school with Komenda College Practice Basic School (2), Komenda M/A JHS A (3), and Komenda M/A JHS B (4) having similar levels of agreement to the statement. Komenda College Practice Basic School (2) and Komenda M/A JHS B (4) had the same level of disagreement to the statement. Komenda M/A JHS A (3) and Aldersgate Methodist Basic School (6) had no disagreement in responding to the statement.

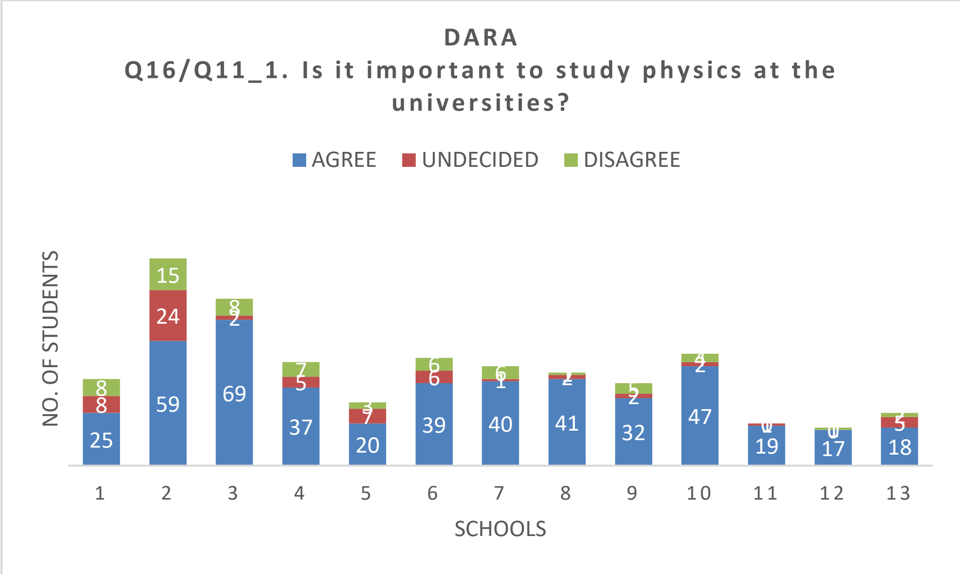
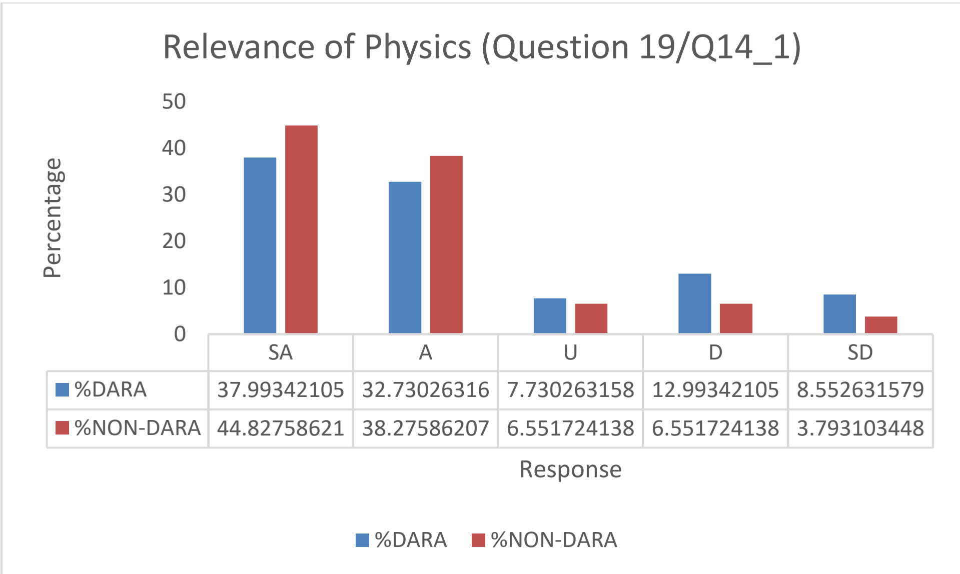


Figure 4.35: Comparison between DARA Schools for question 16/Q11_1

Figure 4.35 shows consensus and quite an evenly spread among the schools. Gbawe Islamic Basic School (11) had no disagreement in responding to the statement. Twinikli International SHS (1) and Presbyterian Boys' SHS-Legon (2) were significantly different from the other schools in responding to the statement.

Question 19/Q14_1: Physics is relevant to the kind of work that you want to do



	SA	A	U	D	SD
%DARA	37.99342105	32.73026316	7.730263158	12.99342105	8.552631579
%NON-DARA	44.82758621	38.27586207	6.551724138	6.551724138	3.793103448

Figure 4.36: Descriptive statistics for question 19/Q14_1

Figure 4.36 shows that 38.0% of DARA students and 44.9% of Non-DARA students strongly agree with the statement, 32.7% of DARA students and 38.3% of Non-DARA students agree with the statement, 7.7% of DARA students and 6.6% of Non-DARA students were undecided with the statement, 13% of DARA students and 6.6% of Non-DARA students disagree with the statement and 8.6% of DARA students and 3.8% of Non-DARA students strongly disagree with the statement ''Physics is relevant to the kind of work that you want to do.'' From the results, it shows that majority of Non-DARA students responded to the statement more than the DARA students. Hence, Non-DARA students believe that Physics is more relevant to the kind of work they want to do.

Using the Mann-Whitney U test for question Q14_1, the DARA group (N= 607) had the higher mean rank (466.68) for the statement ''Physics is relevant to the kind of work that you want to do'' than the Non-DARA group (N= 291) with mean rank (431.66). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =77890.000, p = .002 which is < .05) for the question ''Physics is relevant to the kind of work that you want to do''. The results indicate that with the Non-DARA group Physics is relevant to the kind of work that the students want to do more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''Physics is relevant to the kind of work that you want to do''. A statistically significant difference was found (H = 37.867, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (201.90), and Aldersgate Methodist Basic School (N=25) had the lowest mean rank (117.23). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ''Physics is relevant to the kind of work that you want to do'' than the other schools and Aldersgate Methodist Basic School agree to the statement than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Physics is relevant to the kind of work that you want to do''. A statistically significant difference was found (H = 67.401, p = .000 which is < .05), indicating that the schools differ significantly from each other. GAEC Basic School (N=31) had the highest mean rank (438.73), and Katapor D/M Basic (N=54) had the lowest mean rank (231.39). This shows that GAEC Basic School disagree to the statement ''Physics is relevant to the kind of work that you want to do'' more than the other schools and Katapor D/M Basic School agree to the statement than the other schools.

Comparison between the DARA and Non-DARA schools for question Q14_1 indicates that the DARA schools have a higher Kruskal-Wallis H ($H_{DARA} = 67.401 > H_{Non\text{-}DARA} = 37.867$); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q14_1 (Physics is relevant to the kind of work that I want to do). A strong positive correlation was found ($r = .119$, $p < .01$), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion the direction (positive), strength (strong), value (.0119) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q14_1. A strong positive correlation was found ($r = .101$, $p < .01$), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion the direction (positive), strength (strong), value (.101) and **significance** level « .01) of the correlation.

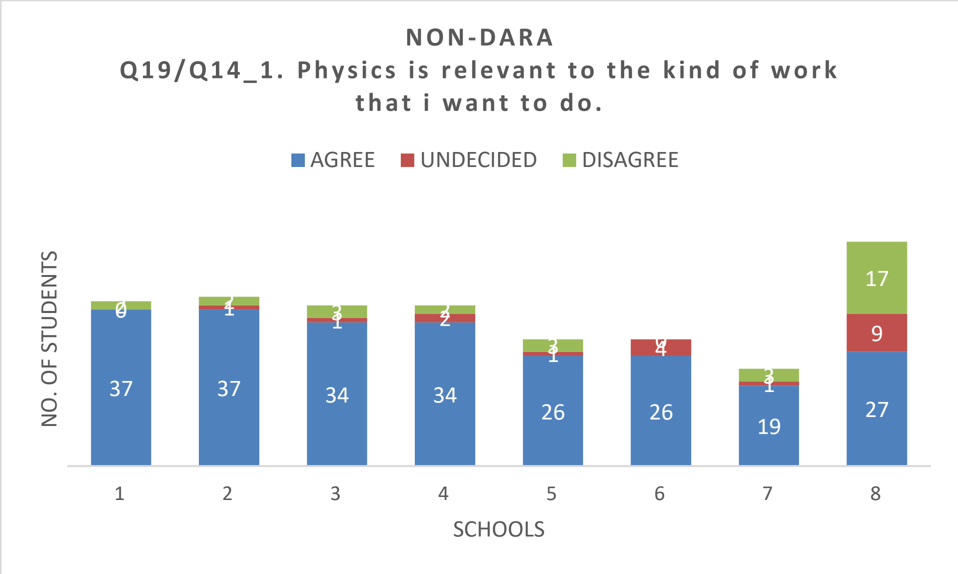


Figure 4.37: Comparison between Non-DARA schools for question 19/Q14_1

Figure 4.37 indicates that Our Lady of Assumption R/C Basic School (8) was an outlier school with more disagreement and Aldersgate Methodist Basic School (6) having no disagreement in responding to the statement. Quite an evenly spread among the schools was observed. Similar levels of agreement between the schools in the way the students responded to the question.

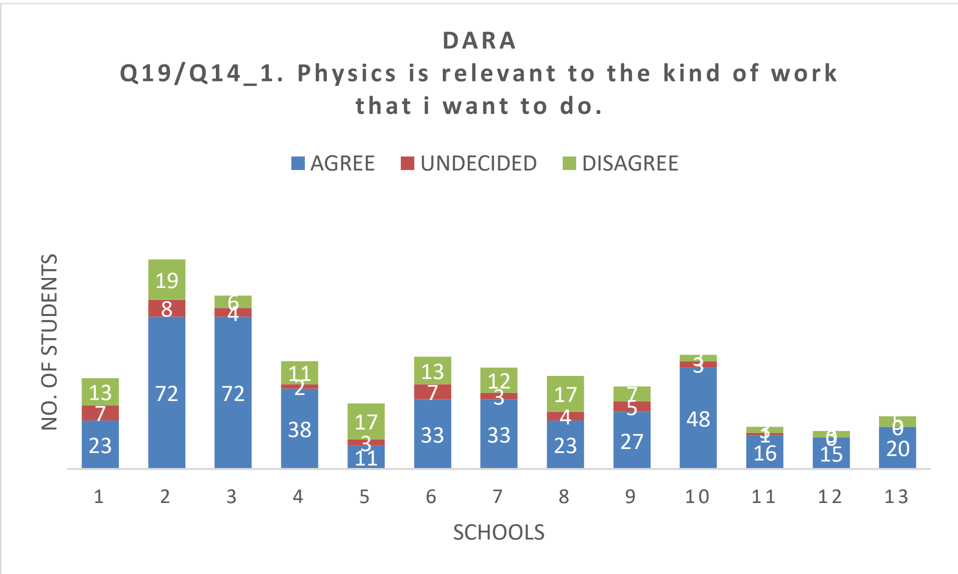
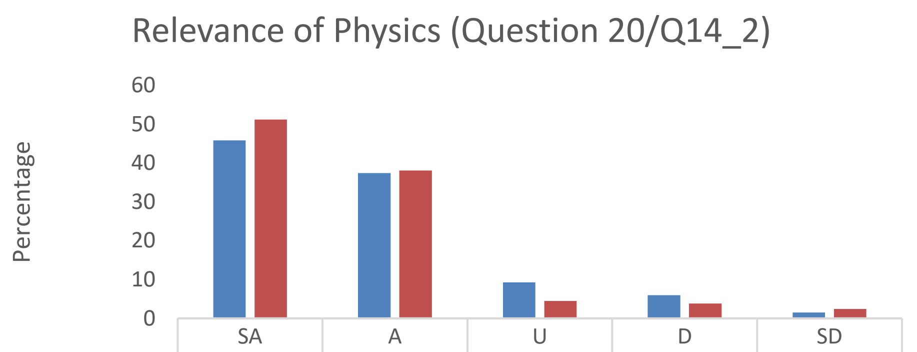


Figure 4.38: Comparison between DARA schools for question 19/Q14_1

Figure 4.38 is not evenly spread out. GAEC Basic School (5) and Kuntunse M/A Basic School 3 (8) are outliers significantly different from the other schools with GAEC Basic School (5) disagreeing considerably more to the statement than any other school.

Question 20/Q14_2: Physics is important for the country's future wealth



	SA	A	U	D	SD
%DARA	45.84717608	37.37541528	9.302325581	5.980066445	1.495016611
%NON-DARA	51.21107266	38.06228374	4.498269896	3.806228374	2.422145329

Figure 4.39: Descriptive statistics for question 20/Q14_2

From Figure 4.39, it shows that 45.8% of DARA students and 51.2% of Non-DARA students strongly agree with the statement, 37.4% of DARA students and 38.1% of Non-DARA students agree with the statement, 9.3% of DARA students and 4.5% of Non-DARA students were undecided with the statement, 6.0% of DARA students and 3.8% of Non-DARA students disagree with the statement and 1.5% of DARA students and 2.4% of Non-DARA students strongly disagree with the statement ''Physics is important for the country's future wealth.'' From the results it shows that majority of Non-DARA students responded to the statement more than the DARA students. Hence, Non –DARA students believe that physics is important for the country's future wealth.

Using the Mann-Whitney U test for question Q14_2, the DARA group (N= 602) had the higher mean rank (455.39) for the statement ''Physics is important for the country's future wealth'' than the Non-DARA group (N= 289) with mean rank (426.44). From the test statistics, it can be concluded that there was no statistically significant difference between the DARA group and the Non-DARA group (U =81337.000, p = .086 which is > .05) for the question ‘’Physics is important for the country’s future wealth’’.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ‘’Physics is important for the country’s future wealth’’. A statistically significant difference was found (H = 16.797, p = .019 which is < .05), indicating that the schools differ significantly from each other. St. Michael & All Angels Anglican JHS (N=30) had the highest mean rank (169.43) and Komenda M/A JHS A (N=38) had the lowest mean rank (119.09). This shows that St. Michael & All Angels Anglican JHS agrees to the statement ‘’Physics is important for the country’s future wealth’’ less than the other schools and Komenda M/A JHS A agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ‘’Physics is important for the country’s future wealth’’. No statistically significant difference was found (H = 19.436, p = .079 which is > .05), indicating that the schools did not differ significantly from each other. Gbawe Islamic Basic School (N=20) had the highest mean rank (367.70) and Kinbu SHTS (N=79) had the lowest mean rank (245.69). This shows that Gbawe Islamic Basic School disagrees to the statement ‘’Physics is important for the country’s future wealth’’ more than the other schools and Kinbu SHTS agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q14_2 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 19.436 > $H_{Non\text{-}DARA}$ = 16.797); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

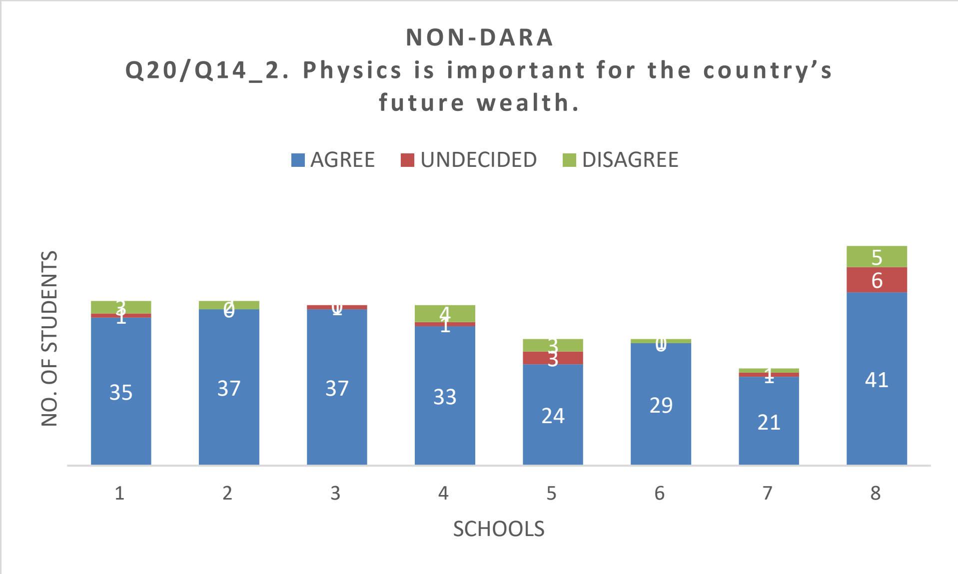


Figure 4.40: Comparison between Non-DARA schools for question 20/Q14_2

Figure 4.40 shows fairly even distribution among the schools. St. Michael & All Angels Anglican JHS (5) and Our Lady of Assumption R/C Basic School (8) were outlier schools and having slightly high disagreement to the statement. Komenda M/A JHS A (3) had no disagreement to the statement. A consensus among the schools was observed.

Question 21/Q14_3: Physics helps me to solve problems in life

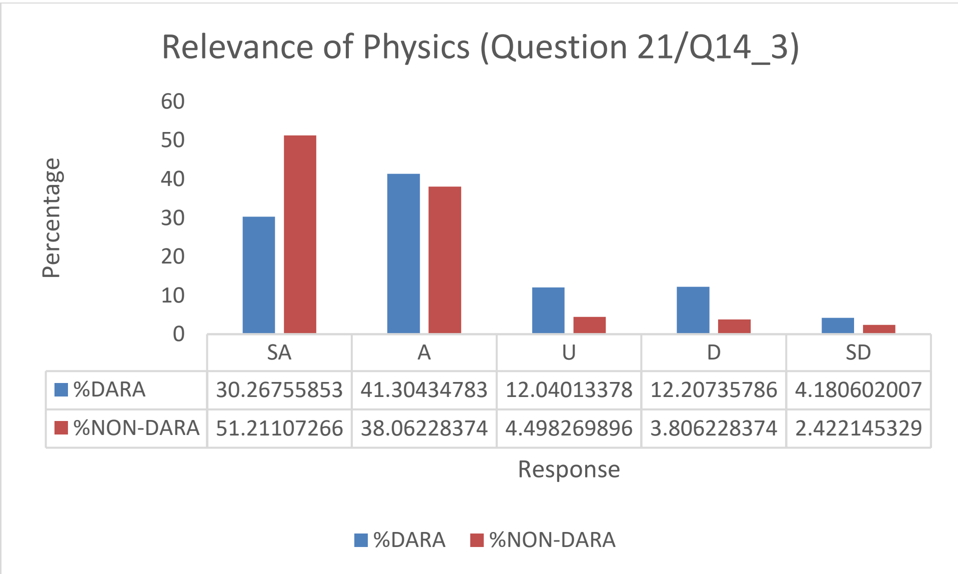


Figure 4.41: Descriptive statistics for question 21/Q14_3

From Figure 4.41, it shows that 30.3% of DARA students and 51.2% of Non-DARA students strongly agree with the statement, 41.3% of DARA students and 38.1% of Non-DARA students agree with the statement, 12.0% of DARA students and 4.5% of Non-DARA students were undecided with the statement, 12.2% of DARA students and 3.8% of Non-DARA students disagree with the statement and 4.2% of DARA students and 2.4% of Non-DARA students strongly disagree with the statement ′′Physics helps me to solve problems in life.′′ From the results it shows that majority of Non-DARA students responded to the statement more than the DARA students. Hence, Physics helps more of the Non –DARA students to solve problems in life.

Using the Mann-Whitney U test for question Q14_3, the DARA group (N=598) had the higher mean rank (465.47) for the statement ′′Physics helps me to solve problems in life′′ than the Non-DARA group (N= 286) with mean rank (394.47). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =71778.000, p = .000 which is < .05) for the question ′′Physics helps me to solve problems in life′′. The results indicate that with the Non-DARA group Physics helps them to solve problems in life more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ′′Physics helps me to solve problems in life′′. A statistically significant difference was found (H = 58.526, p = .000 which is < .05), indicating that the schools differ significantly from each other. Entsua Mensah Preparatory/JHS (N=23) had the highest mean rank (189.39) and Komenda College Practice Basic School (N=39) had the lowest mean rank (80.8). This shows that Entsua Mensah Preparatory/JHS disagrees to the statement ′′Physics helps me to solve problems in life′′ more than the other schools and Komenda College Practice Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ′′Physics helps me to solve problems in life′′. A statistically significant difference was found (H = 55.037, p = .000 which is < .05), indicating that the schools differ significantly from each other. Unity Baptist Academy (N=18) had the highest mean rank (374.92) and Kinbu SHTS (N=80) had the lowest mean rank (217.58). This shows that Unity Baptist Academy disagrees to the statement ''Physics helps me to solve problems in life'' more than the other schools and Kinbu SHTS agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q14_3 indicates that the Non-DARA schools have a higher Kruskal-Wallis H ($H_{Non\text{-}DARA} = 58.526 > H_{DARA} = 55.037$); hence, there were more variations within the Non-DARA schools than the DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q14_3 (Physics helps me to solve problems in life). A strong positive correlation was found *(r = .133, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.133) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q14_3. A strong positive correlation was found *(r = .138, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.138) and **significance** level « .01) of the correlation.

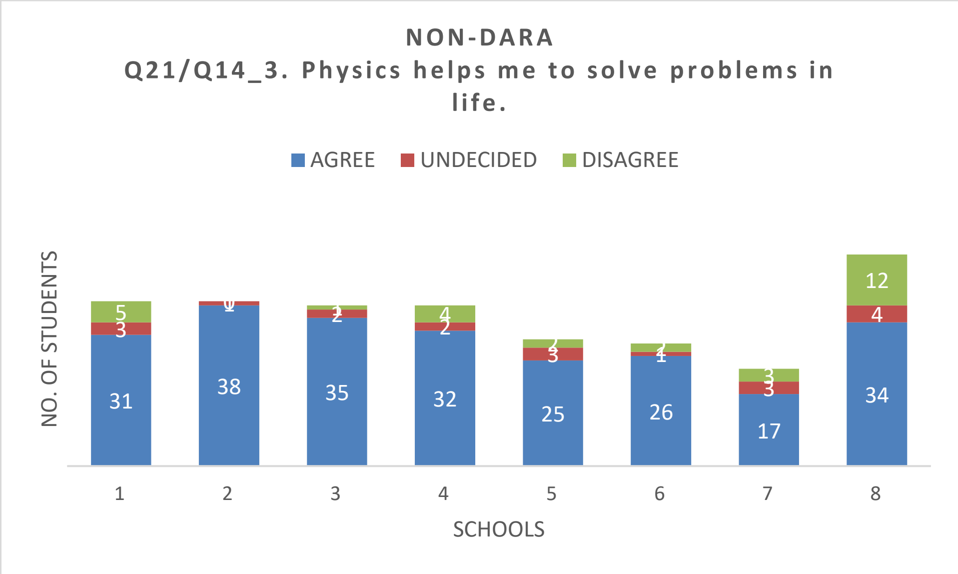


Figure 4.42: Comparison between Non-DARA Schools for question 21/Q14_3

Figure 4.42 indicates that Our Lady of Assumption R/C Basic School (8) was an outlier school with considerably more disagreement and significantly different from the other schools. Komenda College Practice Basic School (2) did not disagree to the statement at all. All schools agree considerably.

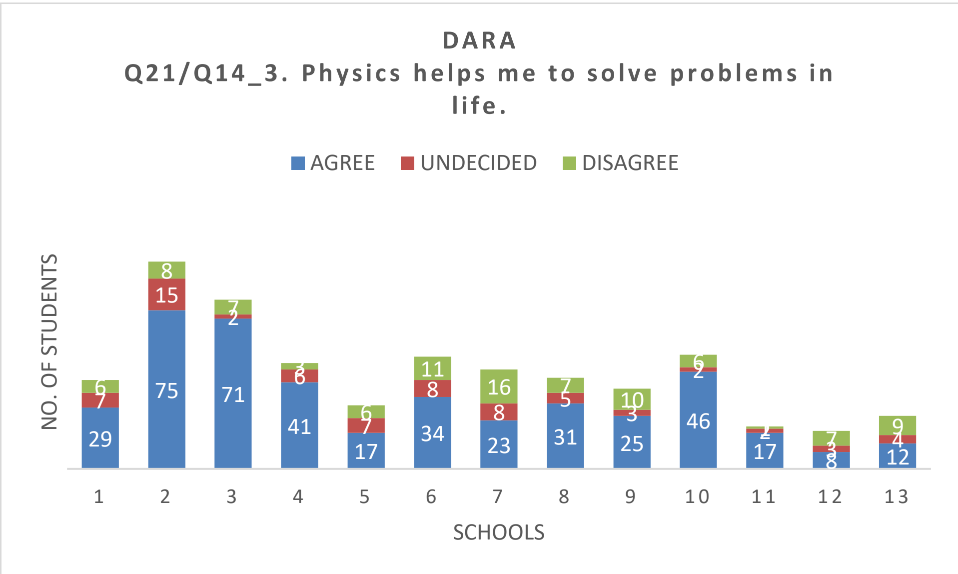


Figure 4.43: Comparison between DARA schools for question 21/Q14_3

Figure 4.43 shows that Kuntunse M/A Basic School 2 (7) was an outlier school with considerably more disagreement to the statement. Variations were more in terms of the levels of agreement and disagreement between the schools. Fairly even spread between the schools.

Question 22/Q15_1: You study Physics because you had no choice / it was compulsory

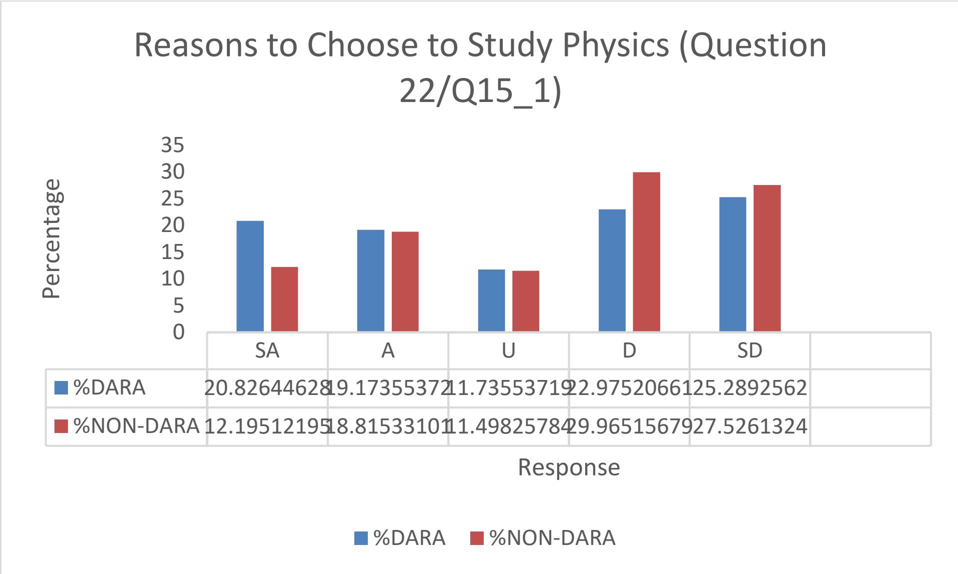


Figure 4.44: Descriptive statistics for question 22/Q15_1

Figure 4.44 shows that 20.8% of DARA students and 12.2% of Non-DARA students strongly agree with the statement, 19.2% of DARA students and 18.8% of Non-DARA students agree with the statement, 11.7% of DARA students and 11.5% of Non-DARA students were undecided with the statement, 22.9% of DARA students and 30.0% of Non-DARA students disagree with the statement and 25.3% of DARA students and 27.5% of Non-DARA students strongly disagree with the statement ''You study Physics because you had no choice / it was compulsory.'' From the above results, it indicates that majority of DARA students study Physics because they had no choice / it was compulsory than the Non-DARA students. Majority of all students disagree, although DARA students agreed more.

Using the Mann-Whitney U test for question Q15_1, the Non-DARA group (N=288) had the higher mean rank (481.61) for the statement ''you study Physics because you had no choice / it was compulsory'' than the DARA group (N= 604) with mean rank (429.76). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =76867.000, p = .004

which is < .05) for the question ''you study Physics because you had no choice / it was compulsory''. The results indicate that with the DARA group (students) would study Physics because they had no choice / it was compulsory more than the Non-DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''you study Physics because you had no choice / it was compulsory''. No statistically significant difference was found (H = 13.782, p = .055 which is > .05), indicating that the schools did not differ significantly from each other. Komenda M/A JHS A (N=38) had the highest mean rank (167.83) and Entsua Mensah Preparatory/JHS (N=22) had the lowest mean rank (112.75). This shows that Komenda M/A JHS A disagrees to the statement ''you study Physics because you had no choice / it was compulsory'' more than the other schools and Entsua Mensah Preparatory/JHS agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''you study Physics because you had no choice / it was compulsory''. A statistically significant difference was found (H = 32.012, p = .001 which is < .05), indicating that the schools differ significantly from each other. Gbawe Islamic Basic School (N=20) had the highest mean rank (380.53) and GAEC Basic School (N=31) had the lowest mean rank (207.76). This shows that Gbawe Islamic Basic School disagrees to the statement ''you study Physics because you had no choice / it was compulsory'' more than the other schools and GAEC Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q15_1 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 32.012 > $H_{Non\text{-}DARA}$ = 13.782); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q15_1 (You study Physics because you had no choice / it was compulsory). A strong negative correlation was found *(r = -.101, p* < .01), indicating a significant relationship between the two variables. DARA students agreed more than the

Non-DARA students to the statement. In conclusion, the direction (negative), strength (strong), value (-.101) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q15_1. A strong negative correlation was found *(r = -.096, p* < .01), indicating a significant relationship between the two variables. DARA students agreed more than the Non-DARA students to the statement. In conclusion, the direction (negative), strength (strong), value (-.096) and **significance** level « .01) of the correlation.

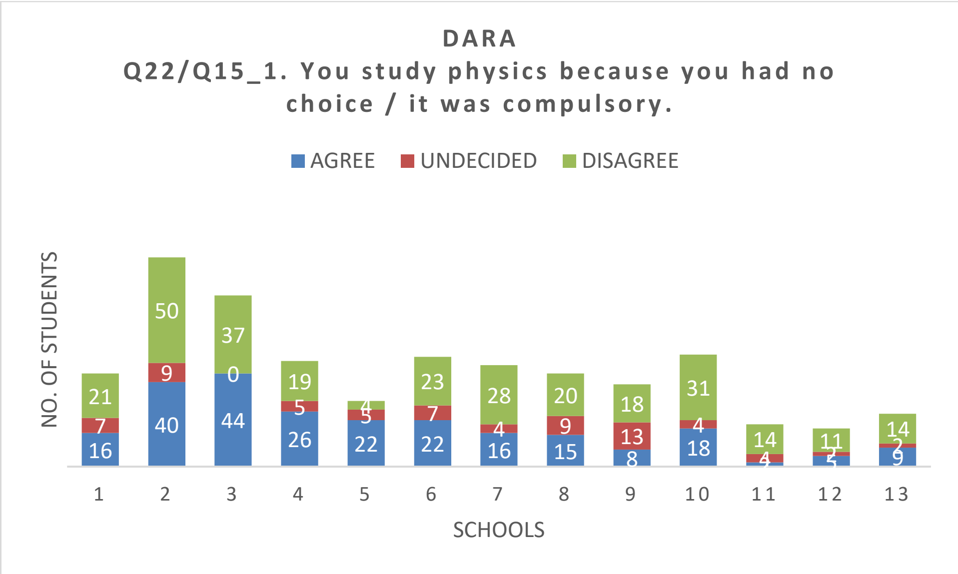


Figure 4.45: Comparison between DARA schools for question 22/Q15_1

Figure 4.45 shows consensus among the schools. Gbawe Islamic Basic School (11) was an outlier school with considerably more disagreement to the statement than all the other schools. There was lot of variations between the schools in responding to the statement.

Question 23/Q15_2: You study Physics because of the range of jobs available

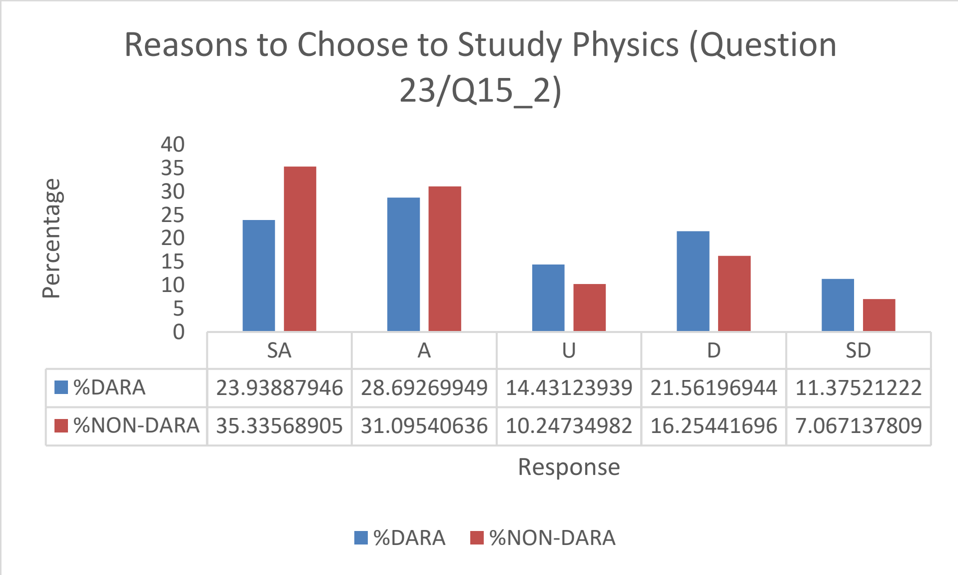


Figure 4.46: Descriptive statistics for question 23/Q15_2

From figure 4.46, the results indicate that majority of Non-DARA students responded to the statement more than the DARA students. Hence more of the Non –DARA students study Physics because of the range of jobs available than the DARA students.

Using the Mann-Whitney U test, for question Q15_2 the DARA group (N=588) had the higher mean rank (459.85) for the statement ''you study Physics because of the range of jobs available'' than the Non-DARA group (N= 284) with mean rank (388.16). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =69768.500, p = .000 which is < .05) for the question ''you study Physics because of the range of jobs available''. The results indicate that with the Non-DARA group (students) would study Physics because of the range of jobs available more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''you study Physics because of the range of jobs available''. A statistically significant difference was found (H = 41.274, p = .000 which is < .05) indicating that the schools differ significantly from each other. Entsua Mensah Preparatory/JHS (N=22) had the highest mean rank (165.93) and Komenda College Practice Basic School (N=40) had the lowest mean rank (81.2). This shows that Entsua

Mensah Preparatory/JHS disagrees to the statement ''you study Physics because of the range of jobs available'' more than the other schools and Komenda College Practice Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''you study Physics because of the range of jobs available''. A statistically significant difference was found ($H = 21.452$, $p = .044$ which is $< .05$), indicating that the schools differ significantly from each other. Tiwnikli International SHS (N=44) had the highest mean rank (349.03), and Kwabenya Community SHS (N=44) had the lowest mean rank (248.89). This shows that Tiwnikli International SHS disagrees to the statement ''you study Physics because of the range of jobs available'' more than the other schools and Kwabenya Community SHS agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q15_2 indicates that the Non-DARA schools have a higher Kruskal-Wallis H ($H_{Non\text{-}DARA} = 41.274 > H_{DARA} = 21.452$); hence, there were more variations within the Non-DARA schools than the DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q15_2 (You study Physics because of the range of jobs available). A strong positive correlation was found *($r = .133$, $p < .01$)*, indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.133) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q15_2. A strong positive correlation was found ($r = .137$, $p < .01$), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.137) and **significance** level « .01) of the correlation.

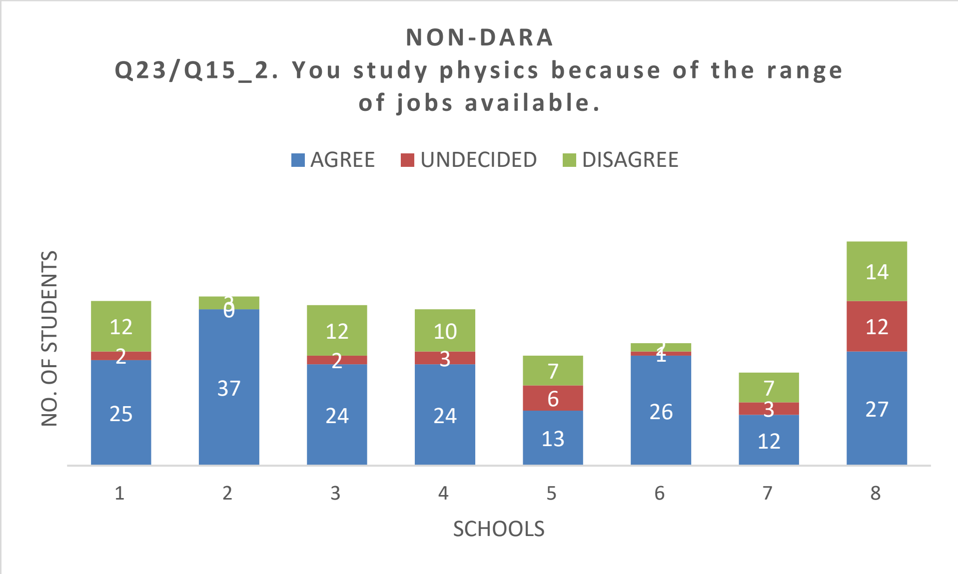


Figure 4.47: Comparison between Non-DARA schools for question 23/Q15_2

Figure 4.47 indicates that St. Michael & All Angels Anglican JHS (5) and Our Lady of Assumption R/C Basic School (8) were significantly different from the other schools ; hence, outlier schools and disagrees a little bit more than any of the schools. The spread was not evenly distributed with small variations among the schools. Fairly consensus and disagreement in responding to the statement. Komenda College Practice Basic School and Entsua Mensah Preparatory/JHS were outliers.

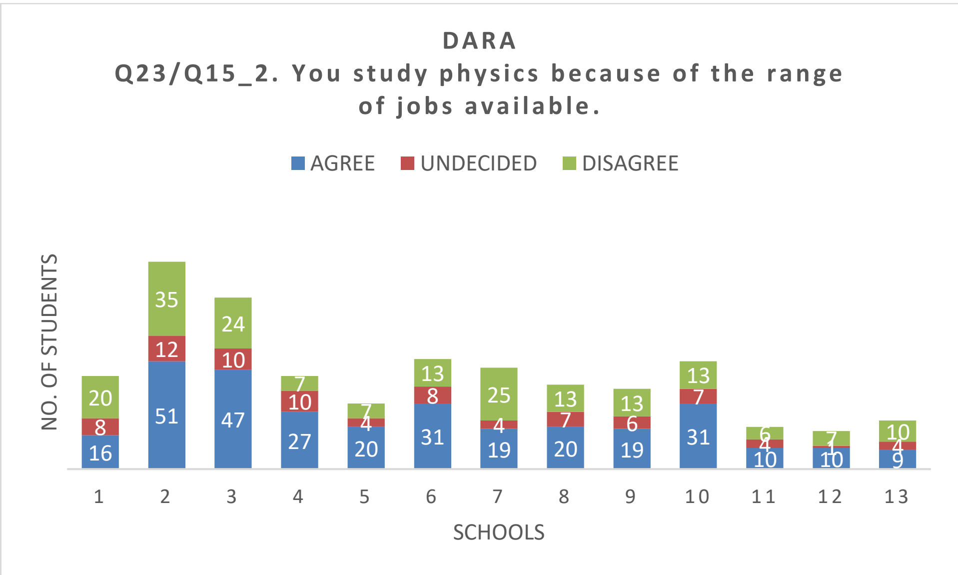


Figure 4.48: Comparison between DARA schools for question 23/Q15_2

Figure 4.48 shows consensus and disagreement among schools. Kuntunse M/A Basic School 2 (7) was an outlier school with considerably more disagreement to the statement. Fairly even distribution of the spread between schools. Tiwnikli International SHS and Kwabenya Community SHS were outliers.

Question 24/Q15_3: You study Physics because you are good at it / it's your best subject

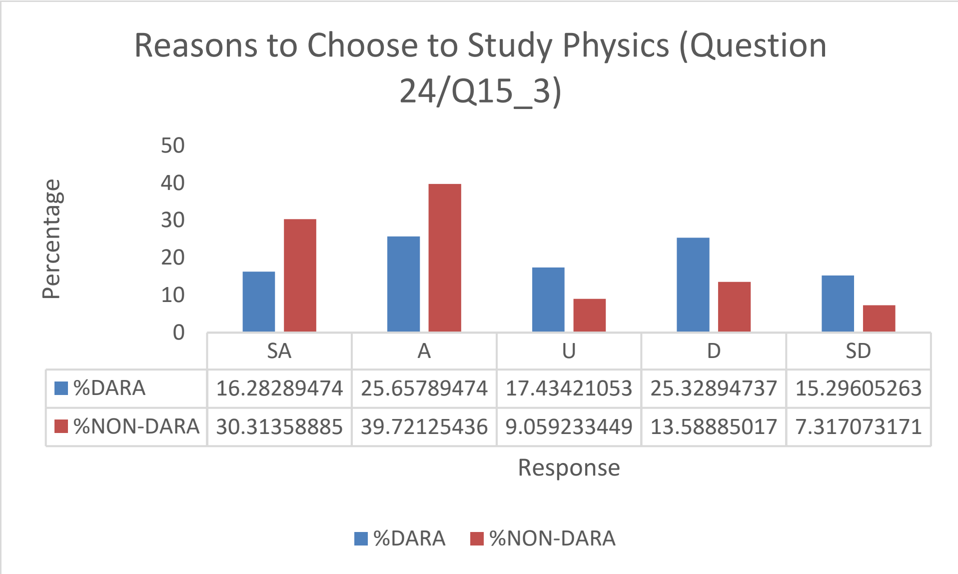


Figure 4.49: Descriptive statistics for question 24/Q15_3

From Figure 4.49, the results indicate that majority of Non-DARA students responded to the statement more than the DARA students. Hence more of the Non –DARA students study Physics because they are good at it / it's your best subject than the DARA students.

Using the Mann-Whitney U test for question Q15_3, the DARA group (N=607) had the higher mean rank (490.07) for the statement ''you study Physics because you are good at it / it's your best subject'' than the Non-DARA group (N= 289) with mean rank (361.19). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =62479.500, p = .000 which is < .05) for the question ''you study Physics because you are good at it / it's your best subject''. The results indicate that with the Non-DARA group (students) would study Physics because they are good at it / it's their best subject more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''you study Physics because you are good at it / it's your best subject''. A statistically significant difference was found (H = 48.099, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (203.98) and Aldersgate Methodist Basic School (N=29) had the lowest mean rank (106.79). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ''you study Physics because you are good at it / it's your best subject'' more than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''you study Physics because you are good at it / it's your best subject''. A statistically significant difference was found (H = 57.661, p = .000 which is < .05), indicating that the schools differ significantly from each other. GAEC Basic School (N=31) had the highest mean rank (411.61), and Jeremite International School (N=24) had the lowest mean rank (189.50). This shows that GAEC Basic School disagrees to the statement ''you study Physics because you are good at it / it's your best subject'' more than the other schools and Jeremite International School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q15_3 indicates that the DARA schools have a higher Kruskal-Wallis H ($H_{DARA} = 57.661 > H_{Non\text{-}DARA} = 48.099$); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q15_3 (You study Physics because you are good at it / it's your best subject). A strong positive correlation was found *(r = .235, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.235) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q15_3. A strong positive correlation was found *(r =* .239*, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.239) and **significance** level « .01) of the correlation.

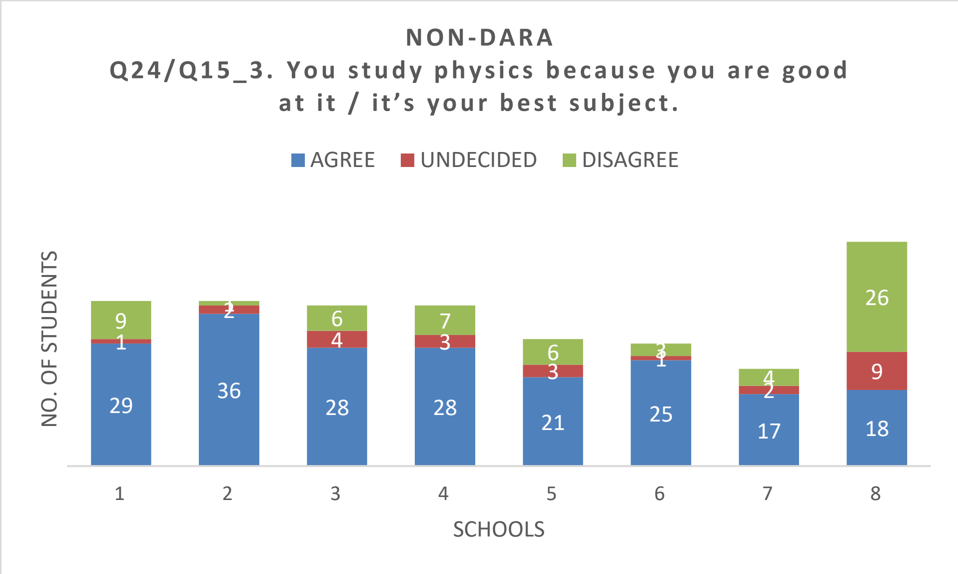


Figure 4.50: Comparison between Non-DARA schools for question 24/Q15_3

Figure 4.50 indicates fair consensus among the schools. Our Lady of Assumption R/C Basic School (8) was an outlier school with considerably much more significant disagreement to the statement than any other school. The spread was not quite evenly distributed between the schools. A little bit of variations among schools in disagreeing to the statement.

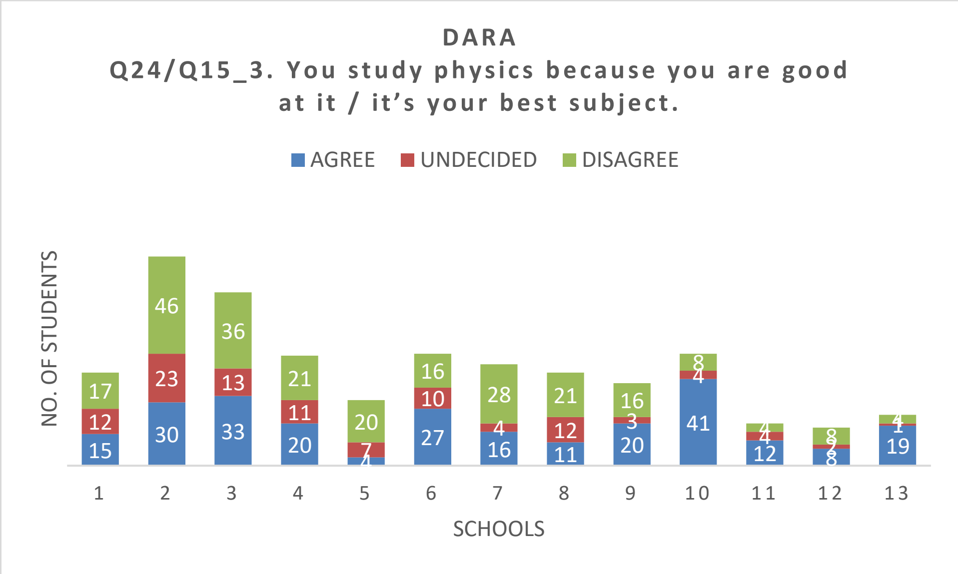
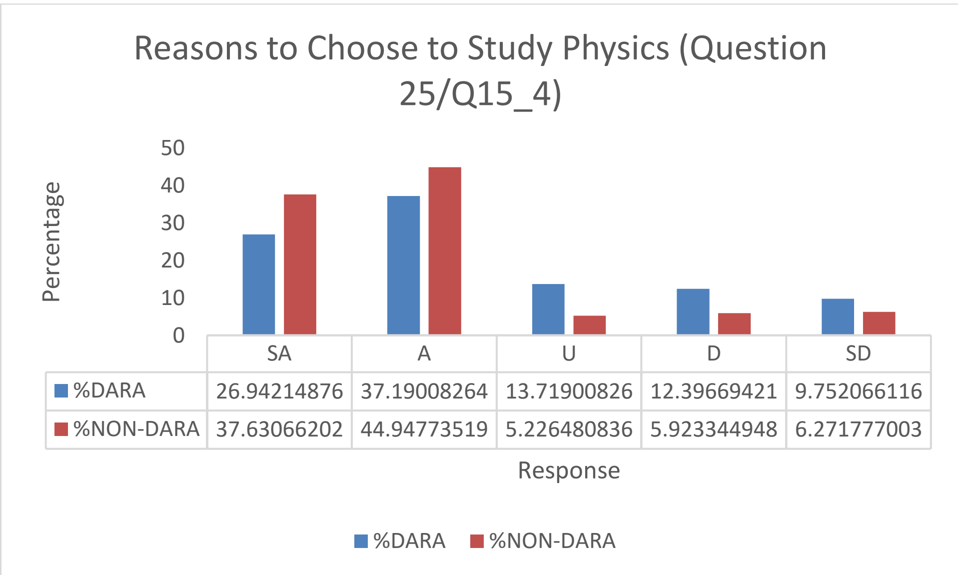


Figure 4.51: Comparison between DARA schools for question 24/Q15_3

Figure 4.51 shows that GAEC Basic School (5) was an outlier school which considerably agrees less to the statement and considerably disagrees more to the statement. 5 was significant different from the other schools in responding to the statement. More variations between schools.

Question 25/Q15_4: You study Physics because you have interest in the subject / enjoy it



	SA	A	U	D	SD
%DARA	26.94214876	37.19008264	13.71900826	12.39669421	9.752066116
%NON-DARA	37.63066202	44.94773519	5.226480836	5.923344948	6.271777003

Figure 4.52: Descriptive statistics for question 25/Q15_4

From Figure 4.52, the results indicate that majority of Non-DARA students responded to the statement more than the DARA students. Hence more of the Non –DARA students study Physics because they have interest in the subject / enjoy it than the DARA students.

Using the Mann-Whitney U test for question Q15_4, the DARA group (N=604) had the higher mean rank (473.90) for the statement ‘’you study Physics because you have interest in the subject / enjoy it’’ than the Non-DARA group (N= 288) with mean rank (389.05). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =70429.000, p = .000 which is < .05) for the question ‘’you study Physics because you have interest in the subject / enjoy it’’. The results indicate that with the Non-DARA group (students) would study Physics because they have interest in the subject / enjoy it more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ‘’you study Physics because you have interest in the subject / enjoy it’’. A statistically significant difference was found (H = 26.181, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption R/C Basic School (N=52) had the highest mean rank (183.13), and Aldersgate Methodist Basic School (N=30) had the lowest mean rank (114.13). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ‘’you study Physics because you have interest in the subject / enjoy it’’ more than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ‘’you study Physics because you have interest in the subject / enjoy it’’. A statistically significant difference was found (H = 70.131, p = .000 which is < .05), indicating that the schools differ significantly from each other. GAEC Basic School (N=31) had the highest mean rank (385.42), and Jeremite International School (N=24) had the lowest mean rank (160.69). This shows that GAEC Basic School disagrees to the statement ‘’you study Physics because you have interest in the subject / enjoy it’’ more than the other schools and Jeremite International School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q15_4 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 70.131 > $H_{Non\text{-}DARA}$ = 26.181); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q15_4 (You study Physics because you have interest in the subject / enjoy it). A strong positive correlation was found *(r = .155, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion the direction (positive), strength (strong), value (.155) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q15_4. A strong positive correlation was found *(r* = .162, *p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion the direction (positive), strength (strong), value (.162) and **significance** level « .01) of the correlation.

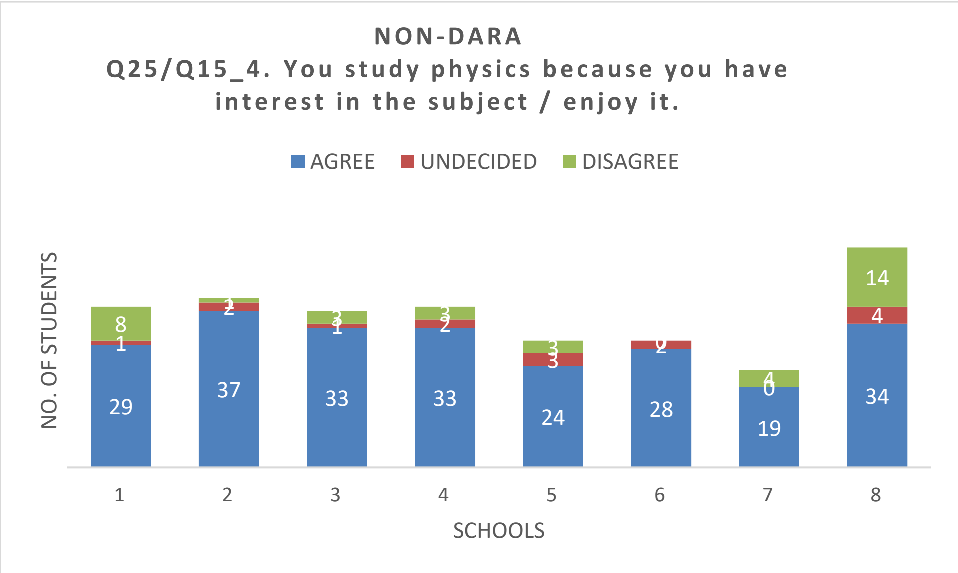


Figure 4.53: Comparison between Non-DARA schools for question 25/Q15_4

Figure 4.53 indicates consensus in responding to the statement among the schools. Our Lady of Assumption R/C Basic School (8) was an outlier school with considerably high disagreement response to the statement. Aldersgate Methodist Basic School (6) had no disagreement in responding to the statement. A little bit of spread among the schools.

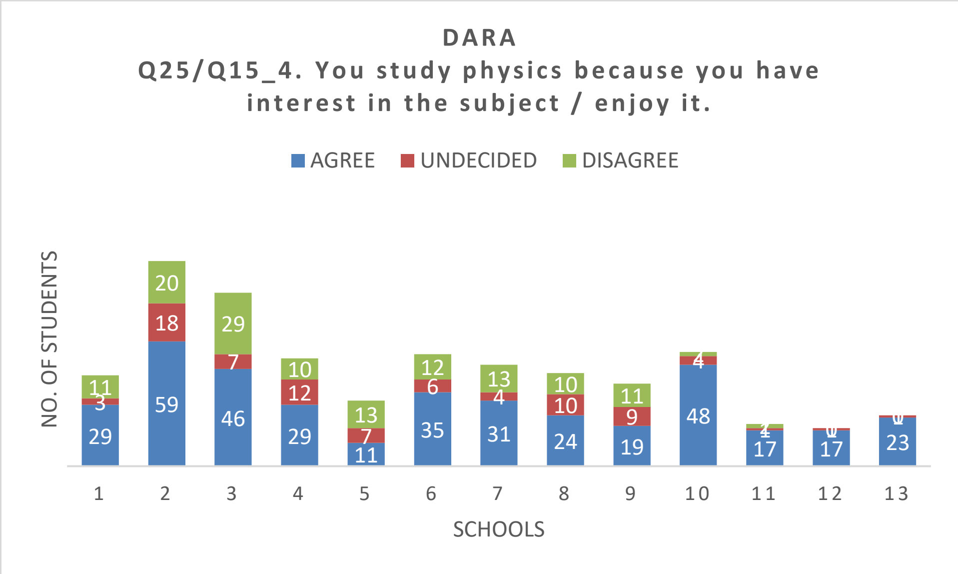


Figure 4.54: Comparison between DARA schools for question 25/Q15_4

Figure 4.54 shows that GAEC Basic School (5) was an outlier school with considerably more disagreement to the statement than all the other schools. Not evenly spread among the various schools. GAEC Basic School (5) agrees less than all the other schools.

Question 26/Q15_5: Will you choose to study Physics at the SHS?

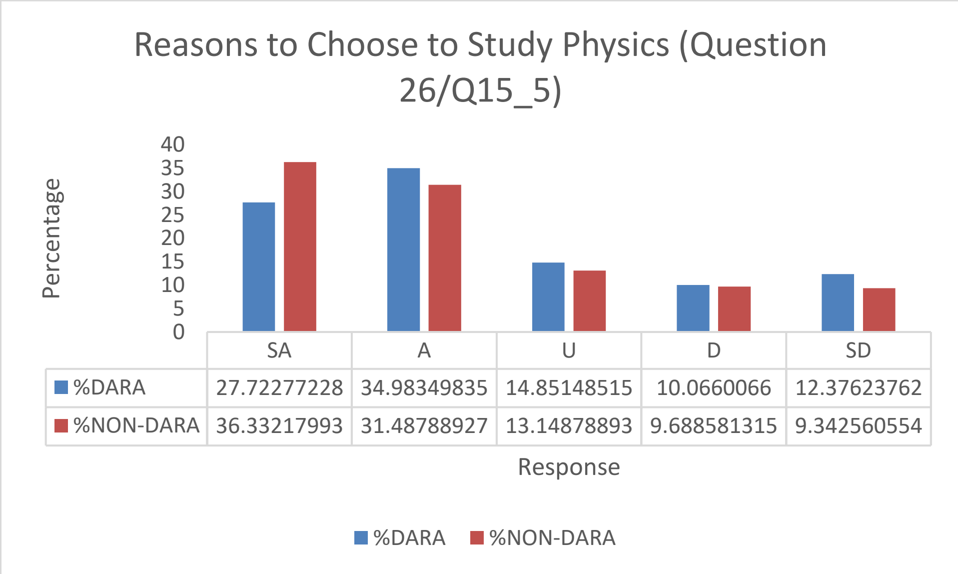


Figure 4.55: Descriptive statistics for question 26/Q15_5

From Figure 4.55, the results indicate that majority of Non-DARA students responded to the statement more than the DARA students. Hence, majority of the Non –DARA students would choose to study Physics at the SHS more than the DARA students.

Using the Mann-Whitney U test for question Q15_5, the DARA group (N=610) had the higher mean rank (465.45) for the statement ''will you choose to study Physics at the SHS?'' than the Non-DARA group (N= 292) with mean rank (422.36). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =80552.500, p = .016 which is < .05) for the question ''will you choose to study Physics at the SHS?''. The results indicate that with the Non-DARA group (students) would choose to study Physics at the SHS more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''Will you choose to study Physics at the SHS?''. A statistically significant difference was found (H = 37.937, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (203.32), and Aldersgate Methodist Basic School (N=30) had the lowest mean rank (108.95). This shows that Our Lady of

Assumption R/C Basic School disagrees to the statement ‘’Will you choose to study Physics at the SHS?’’ more than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ‘’Will you choose to study Physics at the SHS?’’. A statistically significant difference was found (H = 58.276, p = .000 which is < .05), indicating that the schools differ significantly from each other. GAEC Basic School (N=31) had the highest mean rank (409.47), and Gbawe Islamic Basic School (N=20) had the lowest mean rank (209.83). This shows that GAEC Basic School disagrees to the statement ‘’Will you choose to study Physics at the SHS?’’ more than the other schools and Gbawe Islamic Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q15_5 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 58.276 > $H_{Non\text{-}DARA}$ = 37.937); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q15_5 (Will you choose to study Physics at the SHS?). A strong positive correlation was found *(r = .074, p* < .05), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.74) and **significance** level « .05) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q15_5. A strong positive correlation was found *(r* = .080*, p* < .05), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.080) and **significance** level « .05) of the correlation

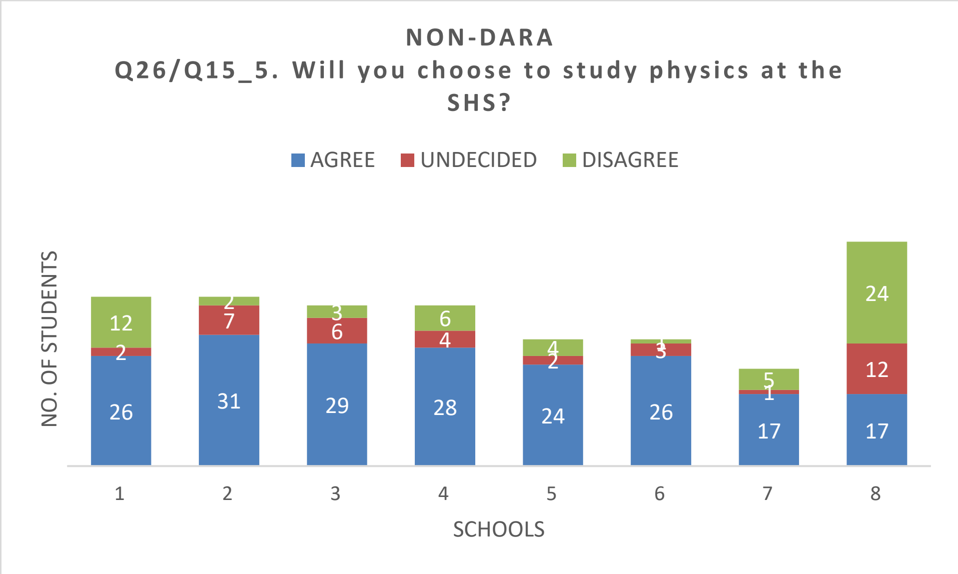


Figure 4.56: Comparison between Non-DARA Schools for question 26/Q15_5

Figure 4.56 indicates that Our Lady of Assumption R/C Basic School (8) was an outlier school and considerably disagreed more and also agreed lesser than the other schools in responding to the statement. Our Lady of Assumption R/C Basic School (8) was significantly different from the other schools in the way the students in the school responded to the statement. Consensus with an exception to Our Lady of Assumption R/C Basic School (8).

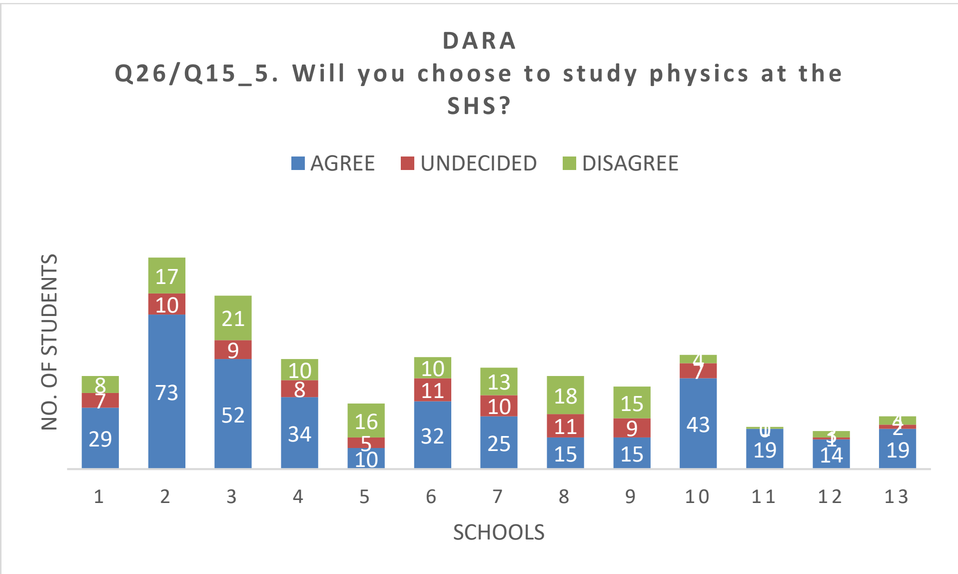
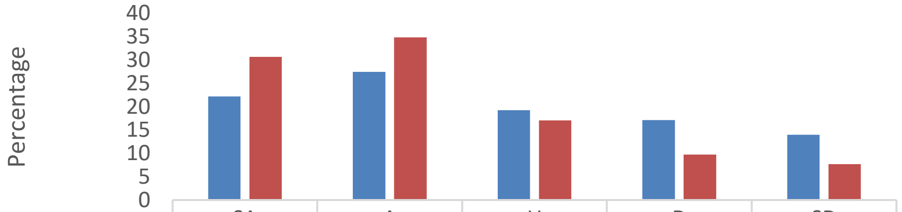


Figure 4.57: Comparison between DARA Schools for question 26/Q15_5

From Figure 4.57, outlier schools were found in GAEC Basic School (5) and Gbawe Islamic Basic School (11). GAEC Basic School (5) had a considerably more disagreement to the statement than the other schools and less agreement. A fair evenly distribution of spread in the schools. A little bit of variations within the schools.

Question 27/Q15_6: Will you choose to study Physics at the Colleges of Education?



	SA	A	U	D	SD
%DARA	22.20394737	27.46710526	19.24342105	17.10526316	13.98026316
%NON-DARA	30.66202091	34.84320557	17.07317073	9.756097561	7.665505226

Figure 4.58: Descriptive statistics for question 27/Q15_6

From Figure 4.58, it shows that 22.2% of DARA students and 30.67% of Non-DARA students strongly agree with the statement, 27.5% of DARA students and 34.8% of Non-DARA students agree with the statement, 19.2% of DARA students and 17.1% of Non-DARA students were undecided with the statement, 17.1% of DARA students and 9.8% of Non-DARA students disagree with the statement and 14.0% of DARA students and 7.7% of Non-DARA students strongly disagree with the statement ''Will you choose to study Physics at the Colleges of Education?'' From the results it indicates that majority of Non-DARA students responded to the statement more than the DARA students. Hence majority of the Non –DARA students would choose to study Physics at the Colleges of Education, but the majority of DARA students would not.

Using the Mann-Whitney U test for question Q15_6, the DARA group (N=608) had the higher mean rank (474.31) for the statement ''will you choose to study Physics at the Colleges of Education?'' than the Non-DARA group (N= 289) with mean rank (395.76) .

From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =72470.000, p = .000 which is < .05) for the question ''will you choose to study Physics at the Colleges of Education?''. The results indicate that with the Non-DARA group (students) would choose to study Physics at the Colleges of Education more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''Will you choose to study Physics at the Colleges of Education?''. A statistically significant difference was found (H = 31.432, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (194.58), and Aldersgate Methodist Basic School (N=29) had the lowest mean rank (112.21). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ''Will you choose to study Physics at the Colleges of Education?'' more than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Will you choose to study Physics at the Colleges of Education?''. A statistically significant difference was found (H = 67.199, p = .000 which is < .05), indicating that the schools differ significantly from each other. GAEC Basic School (N=30) had the highest mean rank (413.50), and Katapor D/M Basic School (N=54) had the lowest mean rank (179.20). This shows that GAEC Basic School disagrees to the statement ''Will you choose to study Physics at the Colleges of Education?'' more than the other schools and Katapor D/M Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q15_6 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 67.199 > $H_{Non\text{-}DARA}$ = 31.432); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q15_6 (Will you choose to study Physics at the Colleges of Education?).

A strong positive correlation was found *(r = .148, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.148) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q15_6. A strong positive correlation was found *(r* = .146*, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.146) and **significance** level « .01) of the correlation.

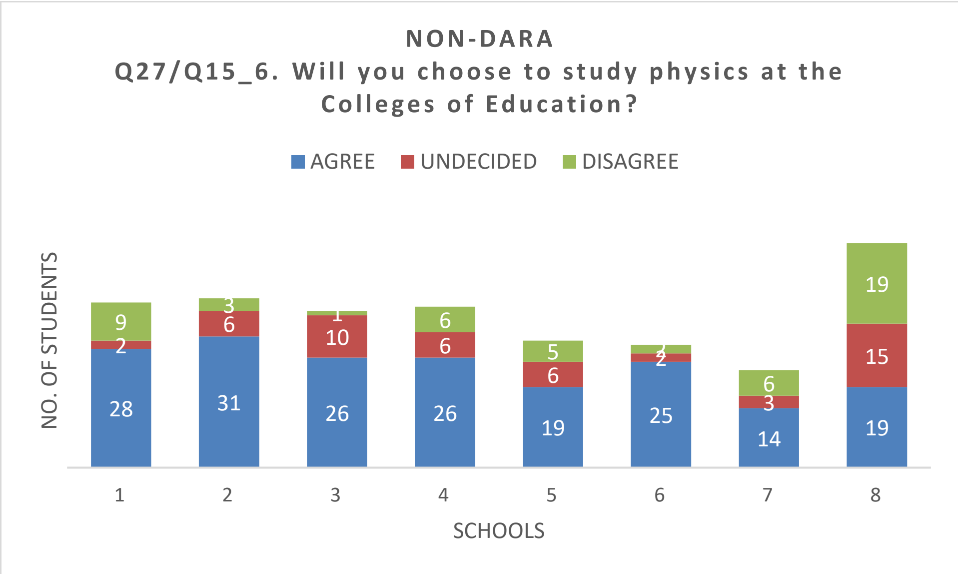


Figure 4.59: Comparison between Non-DARA schools for question 27/Q15_6

Figure 4.59 indicates a little bit of consensus among the schools in agreeing to the statement. Our Lady of Assumption R/C Basic School (8) was an outlier school with high disagreement level and low agreement level in responding to the statement. Quite a bit of evenly distribution/spread. Our Lady of Assumption R/C Basic School (8) was significantly different from all the other schools. Small variations within the schools.

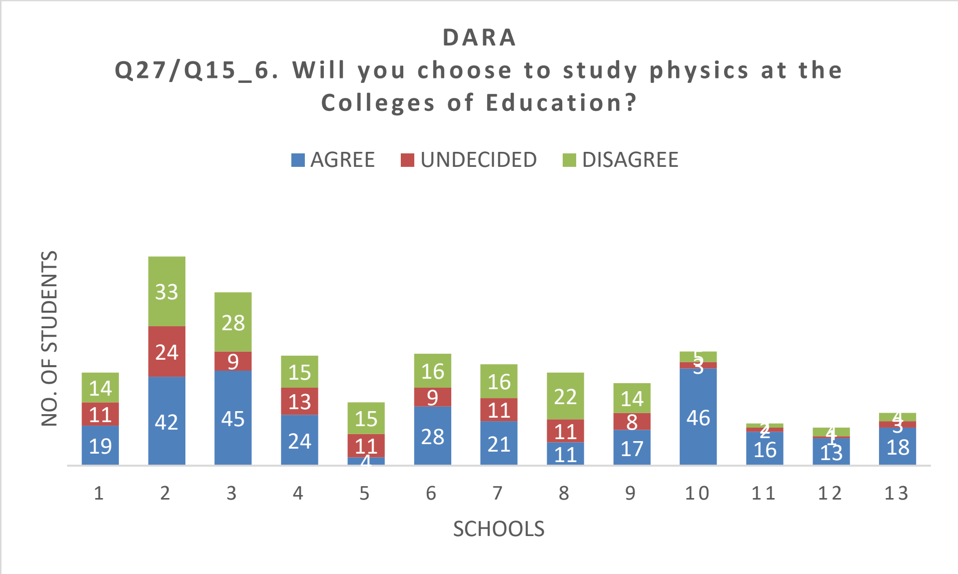


Figure 4.60: Comparison between DARA schools for question 27/Q15_6

Figure 4.60 shows that GAEC Basic School (5) was really an outlier school with disagreement high above the other schools also agrees lesser than all the other schools. Evenly spread with a lot of variations. GAEC Basic School (5) was significantly different from all other schools.

Question 28/Q15_7: Will you choose to study Physics at the Universities?

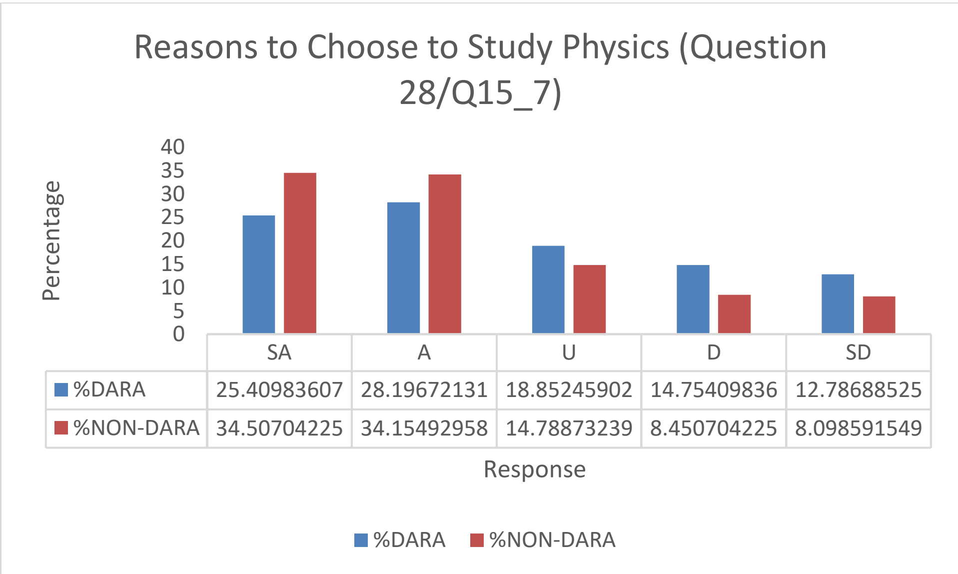


Figure 4.61: Descriptive statistics for question 28/Q15_7

Figure 4.61 shows that 25.4% of DARA students and 34.5% of Non-DARA students strongly agree with the statement, 28.2% of DARA students and 34.2% of Non-DARA students agree with the statement, 18.9% of DARA students and 14.8% of Non-DARA students were undecided with the statement, 14.8% of DARA students and 8.5% of Non-DARA students disagree with the statement and 12.8% of DARA students and 8.1% of Non-DARA students strongly disagree with the statement ''Will you choose to study Physics at the Universities?'' From the results, it indicates that majority of Non-DARA students responded to the statement more than the DARA students. Hence majority of the Non –DARA students would choose to study Physics at the Universities more than the DARA students.

Using the Mann-Whitney U test for question Q15_7, the DARA group (N=609) had the higher mean rank (471.98) for the statement ''will you choose to study Physics at the Universities?'' than the Non-DARA group (N= 286) with mean rank (396.93). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =72480.500, p = .000 which is < .05) for the question ''will you choose to study Physics at the Universities?''. The results indicate that with the Non-DARA group (students) would choose to study Physics at the Universities more than the DARA group.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Will you choose to study Physics at the Universities?''. A statistically significant difference was found (H = 31.423, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption R/C Basic School (N=53) had the highest mean rank (190.99), and Aldersgate Methodist Basic School (N=28) had the lowest mean rank (114.02). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ''Will you choose to study Physics at the Universities?'' more than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Will you choose to study Physics at the Universities?''. A statistically significant difference was found (H = 62.188, p = .000 which is < .05), indicating that the schools differ significantly from each other. GAEC Basic School (N=31) had the highest mean rank (413.08), and Katapor D/M Basic School (N=54) had the lowest mean rank (199.21). This shows that GAEC Basic School disagrees to the statement ''Will you choose to study Physics at the Universities?'' more than the other schools and Katapor D/M Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q15_7 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 62.188 > $H_{Non\text{-}DARA}$ = 31.423); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q15_7 (Will you choose to study Physics at the Universities?). A strong positive correlation was found *(r = .138, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.138) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q15_7. A strong positive correlation was found *(r =* .140*, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the table states the direction (positive), strength (strong), value (.140) and **significance** level « .01) of the correlation.

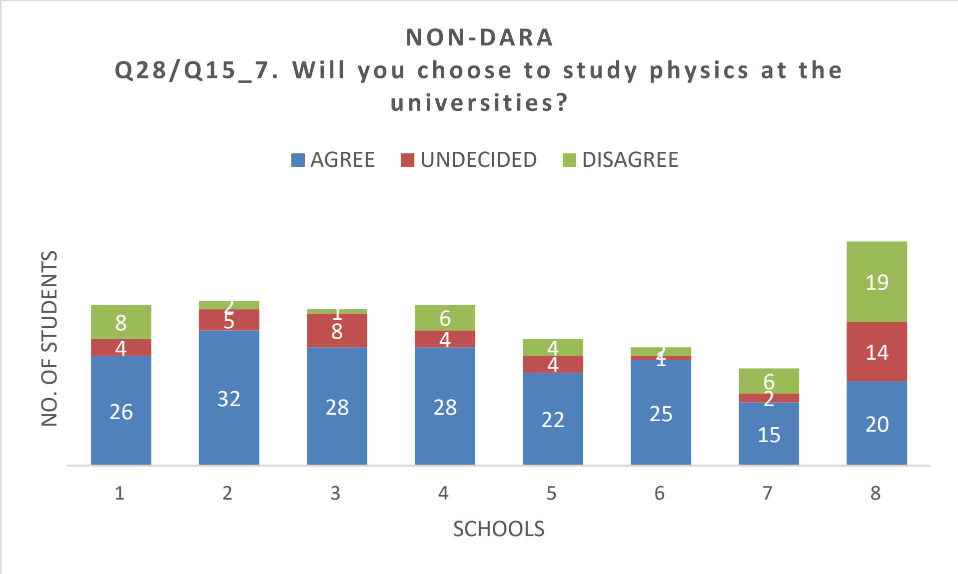


Figure 4.62: Comparison between Non-DARA schools for question 28/Q15_7

Figure 4.62 indicates a little bit of spread between the schools. Consensus among the schools was noticeable. Our Lady of Assumption R/C Basic School (8) was an outlier school which considerably disagrees more and agree less to the statement than any of the other schools. A little bit of variations within the schools. Fairly evenly spread among the schools. Our Lady of Assumption R/C Basic School (8) was different among all the other schools.

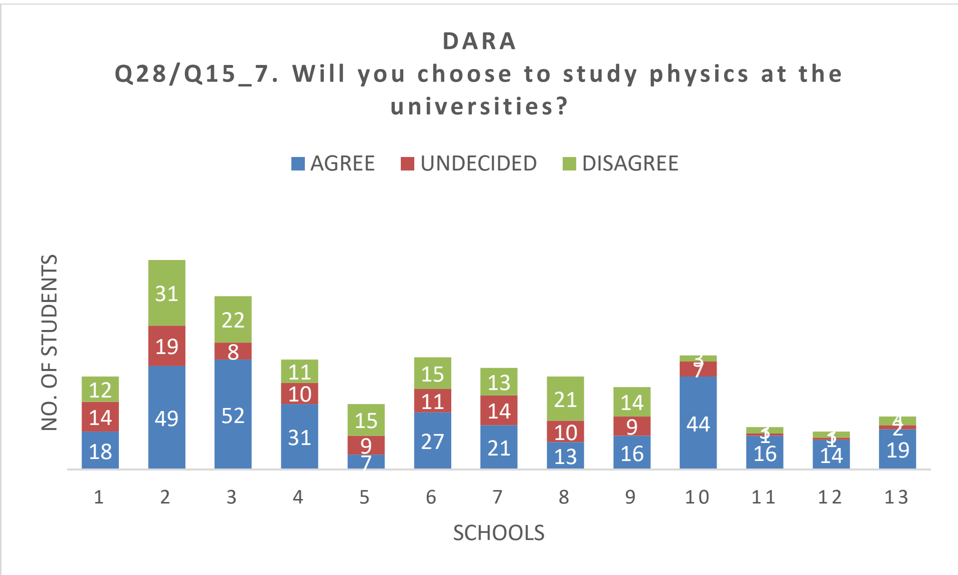


Figure 4.63: Comparison between DARA schools for question 28/Q15_7

From Figure 4.63, GAEC Basic School (5) and Katapor D/M Basic School (10) were found to be outlier schools which had considerably more disagreement and lesser agreement to the statement than any other school. A little bit of spread between the schools.

Question 33/Q20_1: I'm planning a career that uses Physics

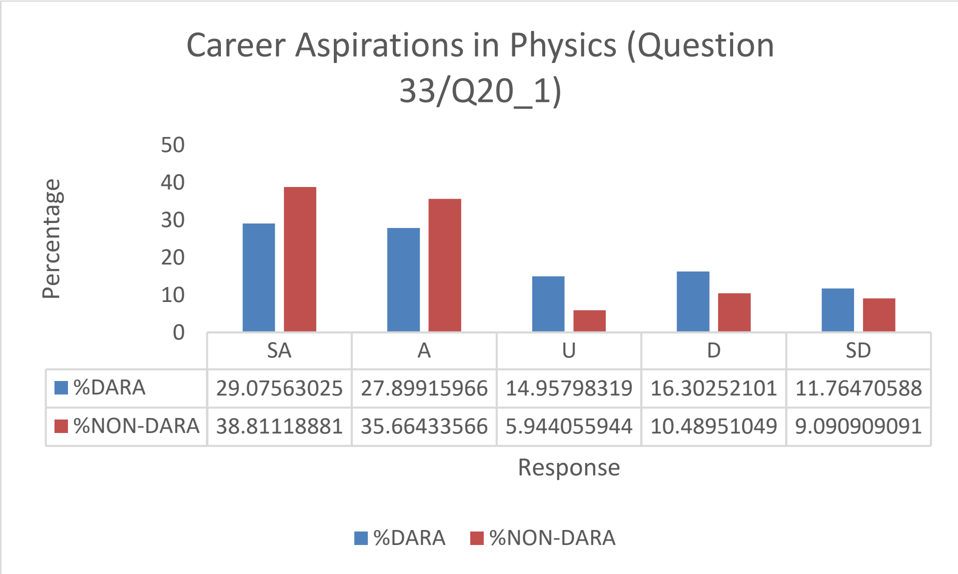


Figure 4.64: Descriptive statistics for question 33/Q20_1

Figure 4.64 shows that 29.1% of DARA students and 38.8% of Non-DARA students strongly agree with the statement, 27.9% of DARA students and 35.7% of Non-DARA students agree with the statement, 15.0% of DARA students and 5.9% of Non-DARA students were undecided with the statement, 16.3% of DARA students and 10.5% of Non-DARA students disagree with the statement and 11.8% of DARA students and 9.1% of Non-DARA students strongly disagree with the statement ''I'm planning a career that uses Physics.'' From the results, it indicates that majority of Non-DARA students responded to the statement more than the DARA students. Hence, majority of the Non –DARA students are planning a career that uses Physics more than the DARA students.

Using the Mann-Whitney U test for question Q20_1, the DARA group (N=594) had the higher mean rank (463.80) for the statement ''I'm planning a career that uses Physics'' than the Non-DARA group (N= 287) with mean rank (393.82). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =71697.500, p = .000 which is < .05) for the question

''I'm planning a career that uses Physics''. The results indicate that with the Non-DARA group (students) are planning a career that uses Physics more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''I'm planning a career that uses Physics''. A statistically significant difference was found (H = 28.397, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption R/C Basic School (N=52) had the highest mean rank (189.06), and Komenda College Practice Basic School (N=40) had the lowest mean rank (113.68). This shows that Our Lady of Assumption R/C Basic School disagrees to the statement ''I'm planning a career that uses Physics'' more than the other schools and Komenda College Practice Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''I'm planning a career that uses Physics''. A statistically significant difference was found (H = 78.359, p = .000 which is < .05), indicating that the schools differ significantly from each other. GAEC Basic School (N=31) had the highest mean rank (417.92), and Katapor D/M Basic School (N=52) had the lowest mean rank (176.68). This shows that GAEC Basic School disagrees to the statement ''I'm planning a career that uses Physics'' more than the other schools and Katapor D/M Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q20_1 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 78.359 > $H_{Non\text{-}DARA}$ = 28.397); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q20_1 (I'm planning a career that uses Physics). A strong positive correlation was found *(r = .128, p* < .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the table states the direction (positive), strength (strong), value (.128) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q20_1. A strong positive correlation was found *(r = .134, p < .01)*, indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.134) and **significance** level « .01) of the correlation.

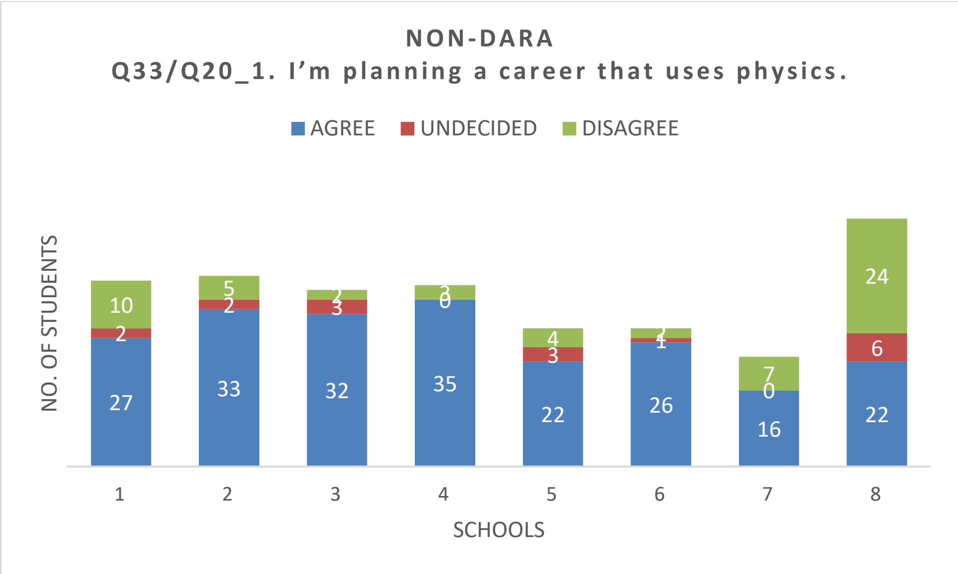


Figure 4.65: Comparison between Non-DARA schools for question 33/Q20_1

Figure 4.65 shows consensus to the statement. A very fair evenly spread among the schools. Komenda M/A JHS B (4) and Entsua Mensah Preparatory/JHS (7) had no undecided response to the statement. A little bit of variations between the schools. Our Lady of Assumption R/C Basic School (8) was an outlier school having a more considerably disagreement and lesser agreement to the statement.

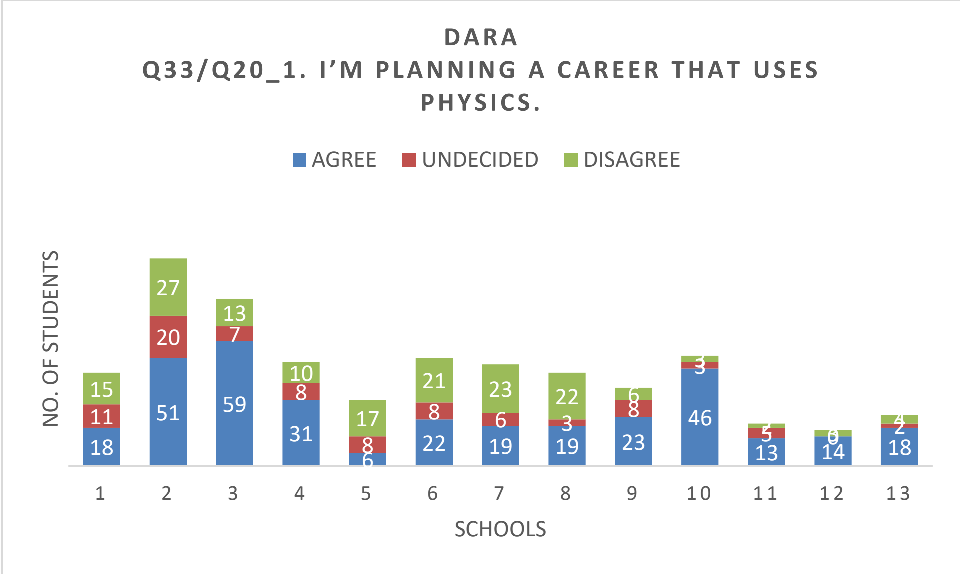


Figure 4.66: Comparison between DARA schools for question 33/Q20_1

From Figure 4.66, there were more variations among the schools. GAEC Basic School (5) and Katapor D/M Basic School (10) were outlier schools with considerably more disagreement and less agreement to the statement than any other school. Spread a little bit of evenly distribution. GAEC Basic School (5) was significantly different from all the other schools which made the Kruskal Wallis test to have significant results.

Question 38/Q25_1: Job satisfaction is more important to me than a good salary

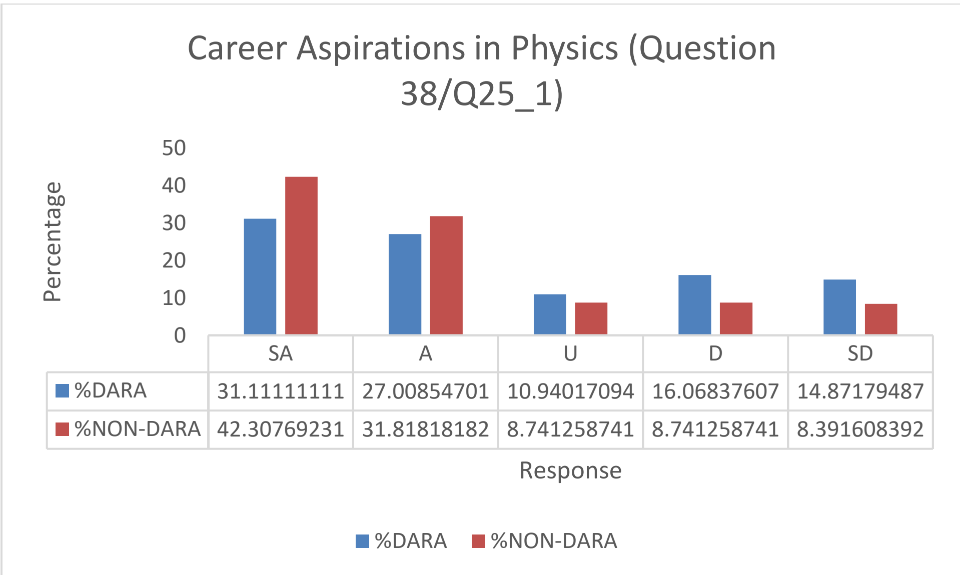


Figure 4.67: Descriptive statistics for question 38/Q25_1

From Figure 4.67, the results indicates that majority of Non-DARA students agreed with the statement more than the DARA students. Hence, majority of the Non –DARA students believe that job satisfaction is more important to them than a good salary more than the DARA students. Stronger for Non-DARA students.

Using the Mann-Whitney U test for question Q25_1, the DARA group (N=584) had the higher mean rank (461.48) for the statement ‘’Job satisfaction is more important to me than a good salary’’ than the Non-DARA group (N= 287) with mean rank (384.16). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =68926.000, p = .000 which is < .05) for the question ‘’Job satisfaction is more important to me than a good salary’’. The results indicate that with the Non-DARA group (students) think job satisfaction is more important to them than a good salary more than the DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ‘’Job satisfaction is more important to me than a good salary’’. A statistically significant difference was found (H = 21.689, p = .003 which is < .05), indicating that the schools differ significantly from each other. Entsua Mensah Preparatory/JHS (N=23) had the highest mean rank (172.87), and Aldersgate Methodist Basic School (N=28) had the lowest mean rank (110.20). This shows that Entsua Mensah Preparatory/JHS disagrees to the statement ‘’Job satisfaction is more important to me than a good salary’’ more than the other schools and Aldersgate Methodist Basic School agree to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ‘’Job satisfaction is more important to me than a good salary’’. A statistically significant difference was found (H = 41.388, p = .000 which is < .05), indicating that the schools differ significantly from each other. GAEC Basic School (N=30) had the highest mean rank (410.03), and Kuntunse M/A Basic School 2 (N=48) had the lowest mean rank (224.31). This shows that GAEC Basic School disagrees to the statement ‘’Job satisfaction is more important to me than a good salary’’ more than the other schools and Kuntunse M/A Basic School agree to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q25_1 indicates that the DARA schools have a higher Kruskal-Wallis H ($H_{DARA} = 41.388 > H_{Non\text{-}DARA} = 21.689$); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q25_1 (Job satisfaction is more important to me than a good salary). A strong positive correlation was found *(r = .154, p <* .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the direction (positive), strength (strong), value (.154) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q25_1. A strong positive correlation was found *(r =* .150*, p <* .01), indicating a significant relationship between the two variables. DARA students disagreed more than the Non-DARA students to the statement. In conclusion, the table states the direction (positive), strength (strong), value (.150) and **significance** level « .01) of the correlation.

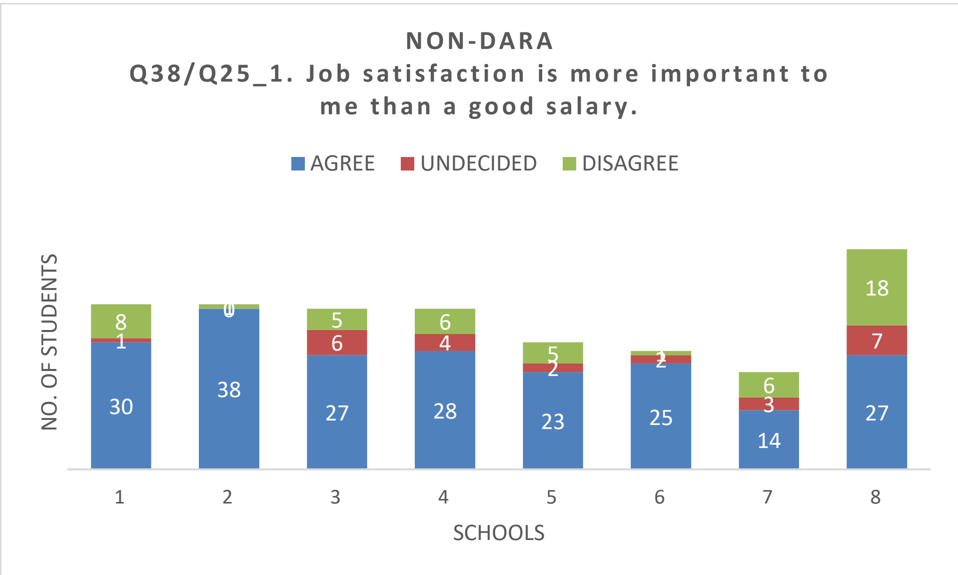


Figure 4.68: Comparison between Non-DARA Schools for QUESTION 38/Q25_1

Figure 4.68 indicates quite a bit of evenly spread among the schools. Little bit of variations between the schools. Fair consensus to the statement. Our Lady of Assumption R/C Basic School (8) was an outlier school with a high level of disagreement and a lesser level of agreement to the statement and also significantly different from the other schools. Komenda College Practice Basic School (2) and Aldersgate Methodist Basic School were also outliers.

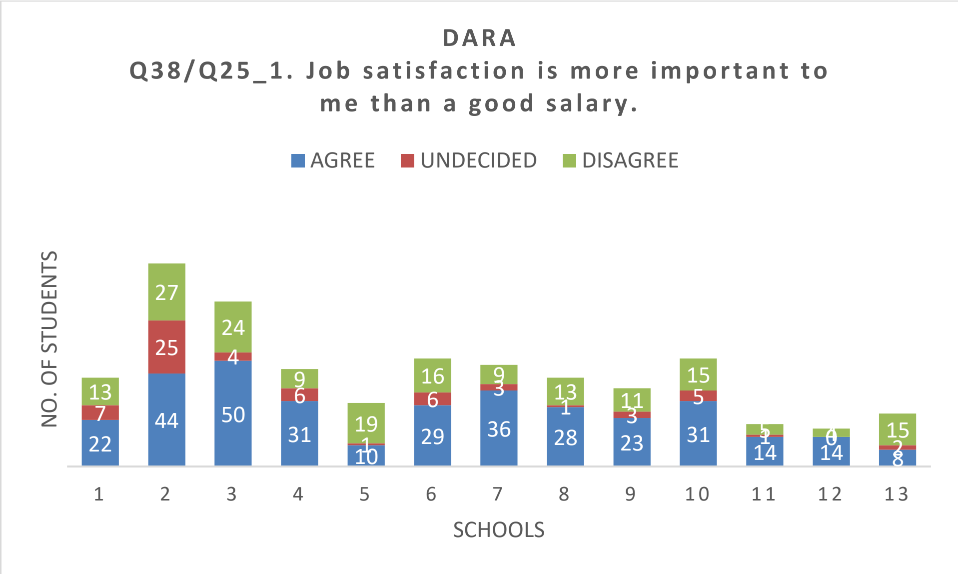


Figure 4.69: Comparison between DARA schools for question 38/Q25_1

Figure 4.69 indicates that GAEC Basic School (5) and Jerremite International School (13) were outlier schools with similar levels of agreement and disagreement to the statement. Jerremite International School (13) had more students responding to undecided than GAEC Basic School (5). A little bit of variations among the schools. Fair consensus and disagreement within the schools. Fairly spread between schools.

Question 39/Q26_1: Have you been taught the topic ‘‘telescopes’’ in class?

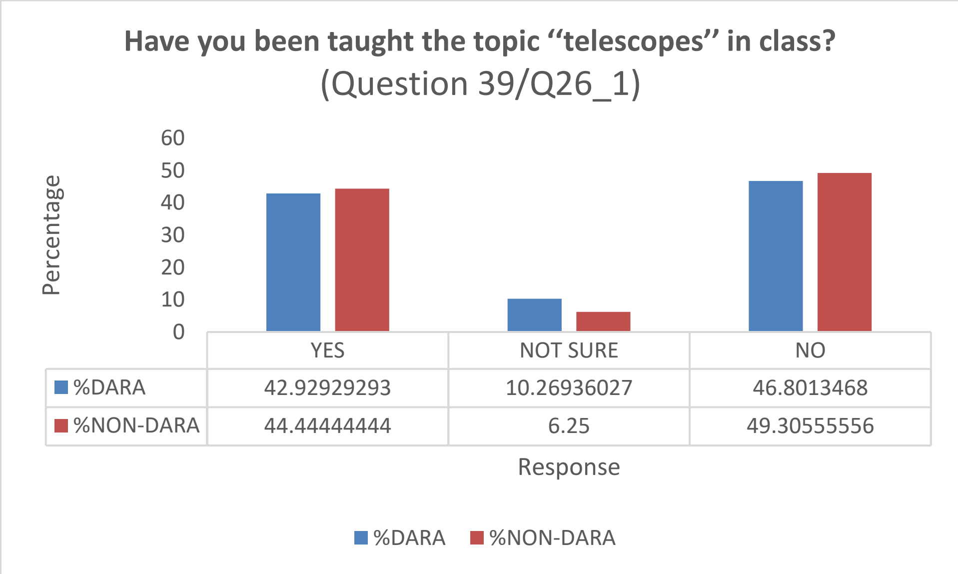


Figure 4.70: Descriptive statistics for question 39/Q26_1

Figure 4.70 shows that 42.9% of DARA students and 44.4% of Non-DARA students responded ‘’yes’’ to the statement, 10.3% of DARA students and 6.3% of Non-DARA students responded ‘’not sure’’ to the statement and 46.8% of DARA students and 49.3% of Non-DARA students responded ‘’no’’ to the statement ‘’Have you been taught the topic ‘‘telescopes’’ in class?’’ From the results above it shows that DARA students remember being taught the topic ‘‘telescopes’’ in class more than the Non-DARA students. The results were fairly even.

Using the Mann-Whitney U test for question Q26_1, the DARA group (N= 610) had the higher mean rank (458.51) for the statement ‘’Have you been taught the topic ‘‘telescopes’’ in class?’’ than the Non-DARA group (N= 292) with mean rank (436.86). From the test statistics, it can be concluded that there was no statistically significant difference between the DARA group and the Non-DARA group (U =84786.000, p = .198 which is > .05) for the question ‘’Have you been taught the topic ‘‘telescopes’’ in class?’’.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ‘‘have you been taught the topic ‘‘telescopes’’ in class?’’. A statistically significant difference was found (H = 38.893, p = .000 which is < .05), indicating that the schools differ significantly from each other. Our Lady of Assumption

R/C Basic School (N=53) had the highest mean rank (185.36), and Komenda M/A JHS B (N=38) had the lowest mean rank (105.36). This shows that Our Lady of Assumption R/C Basic School responded ''no'' to the statement ''have you been taught the topic ''telescopes'' in class?'' more than the other schools and Komenda M/A JHS B responded ''yes'' to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''have you been taught the topic ''telescopes'' in class?''. A statistically significant difference was found (H = 70.904, p = .000 which is < .05), indicating that the schools differ significantly from each other. Tiwnikli International SHS (N=44) had the highest mean rank (385.07), and Katapor D/M Basic School (N=54) had the lowest mean rank (196.50). This shows that Tiwnikli International SHS DARA students answered ''no'' to the statement ''have you been taught the topic ''telescopes'' in class?'' more than the other schools and Katapor D/M Basic School answered ''yes'' to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q26_1 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 70.904 > $H_{Non\text{-}DARA}$ = 38.893); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

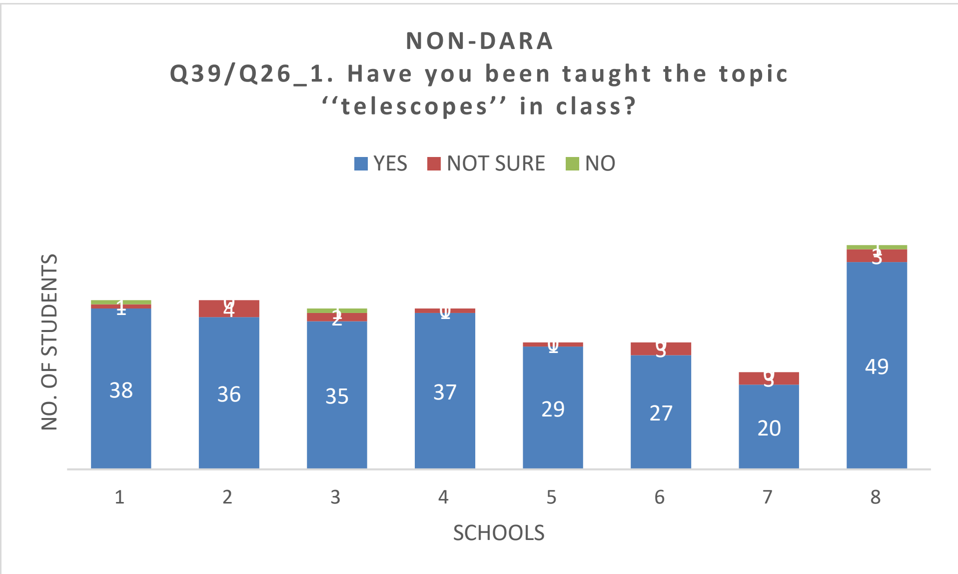


Figure 4.71: Comparison between Non-DARA schools for question 39/Q26_1

Figure 4.71 shows that Entsua Mensah Preparatory/JHS (7) was an outlier school with considerably more ''not sure'' responses by students than any other school and also the students had no ''no'' response to the statement likewise Komenda College Practice Basic School (2), Komenda M/A JHS B (4), St. Michael & All Angels Anglican JHS (5) and Aldersgate Methodist Basic School (6). A little bit of variations within the schools. Quite a bit of spread. Entsua Mensah Preparatory/JHS (7) was significantly different from the other schools and that contributed to the significant difference of the Kruskal Wallis test.

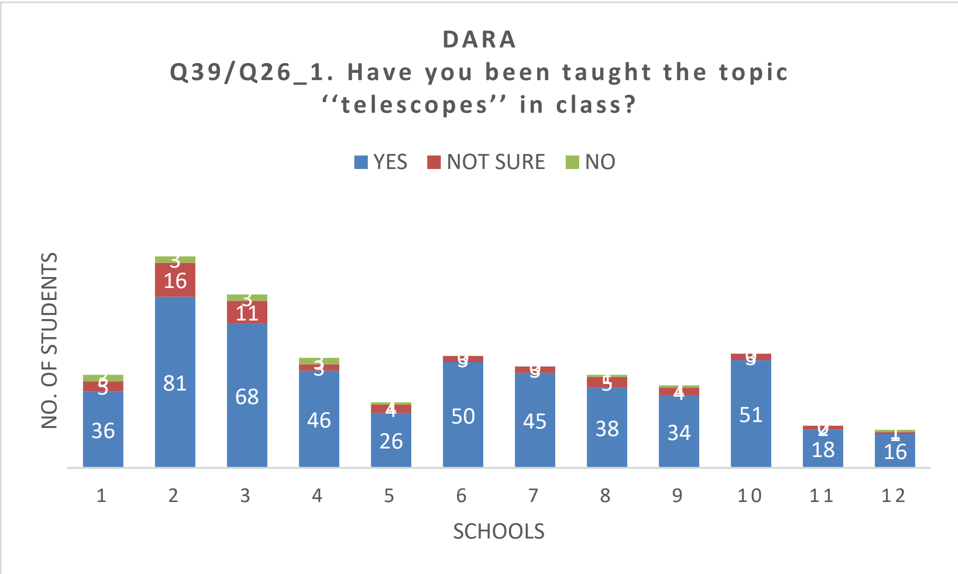


Figure 4.72: Comparison between DARA schools for question 39/Q26_1

From Figure 4.72, there was consensus on responding ''yes'' to the statement among the various schools. No outliers. An evenly spread/distribution. Majority of the schools responded ''yes'' to the statement, which shows that they have been taught the topic ''telescopes'' in class. Kuntunse M/A Basic School 1 (6), Kuntunse M/A Basic School 2 (7), Katapor D/M Basic School (10), and Gbawe Islamic Basic School (11) had no ''no'' response to the statement. Also, Kuntunse M/A Basic School 1 (6), Kuntunse M/A Basic School 2 (7), and Katapor D/M Basic School (10) had the same level of responding ''yes'' and ''not sure'' to the statement. A little bit of variations between the schools.

Question 40/Q26_2: Are you aware of the DARA project in Ghana?

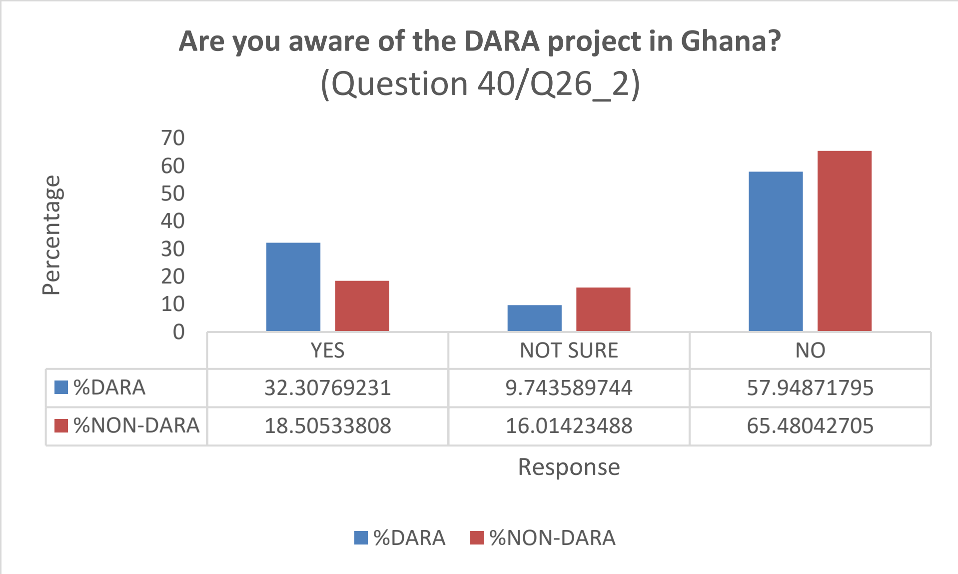


Figure 4.73: Descriptive statistics for question 40/Q26_2

From Figure 4.73, the results shows that majority of the DARA students are much more aware of the DARA project in Ghana than the Non-DARA students.

Using the Mann-Whitney U test for question Q26_2, the Non-DARA group (N=292) had the higher mean rank (498.00) for the statement ''Are you aware of the DARA project in Ghana?'' than the DARA group (N= 610) with mean rank (429.24) . From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =75481.500, p = .000 which is < .05) for the question ''Are you aware of the DARA project in Ghana?''. The results indicate that the DARA group (students) are aware of the DARA project in Ghana more than the Non-DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''Are you aware of the DARA project in Ghana?''. No statistically significant difference was found (H = 8.208, p = .315 which is > .05), indicating that the schools did not differ significantly from each other. For question Q26_2 the various schools for the Non-DARA schools with their N=sample sizes and mean ranks. Aldersgate Methodist Basic School (N=30) had the highest mean rank (166.83), and St. Michael & All Angels Anglican JHS (N=30) had the lowest mean rank

(127.95). This shows that Aldersgate Methodist Basic School answered ''no'' to the statement ''Are you aware of the DARA project in Ghana?'' more than the other schools and St. Michael & All Angels Anglican JHS answered ''yes'' to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Are you aware of the DARA project in Ghana?''. A statistically significant difference was found (H = 99.899, p = .000 which is < .05), indicating that the schools differ significantly from each other. Presbyterian Boys' SHS-Legon (N=100) had the highest mean rank (384.93), and Jeremite International School (N=25) had the lowest mean rank (196.78). This shows that Presbyterian Boys' SHS-Legon responded ''no'' to the statement ''Are you aware of the DARA project in Ghana?'' more than the other schools and Jeremite International School responded ''yes'' to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q26_2 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 99.899 > $H_{Non\text{-}DARA}$ = 8.208); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q26_2 (Are you aware of the DARA project in Ghana?). A weak negative correlation that was not significant was found *(r = -.043, p* > .05), indicating not a significant relationship between the two variables. DARA students answered ''yes'' more than the Non-DARA students to the statement. In conclusion, the direction (negative), strength (weak), value (-.043) and **significant** difference = .195 which is > .05, the p-value) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q26_2. A strong negative correlation was found *(r =* -.140*, p* < .01), indicating a significant relationship between the two variables. DARA students answered ''yes'' more than the Non-DARA students to the statement. In conclusion, the direction (negative), strength (strong), value (-.140) and **significance** level « .01) of the correlation.

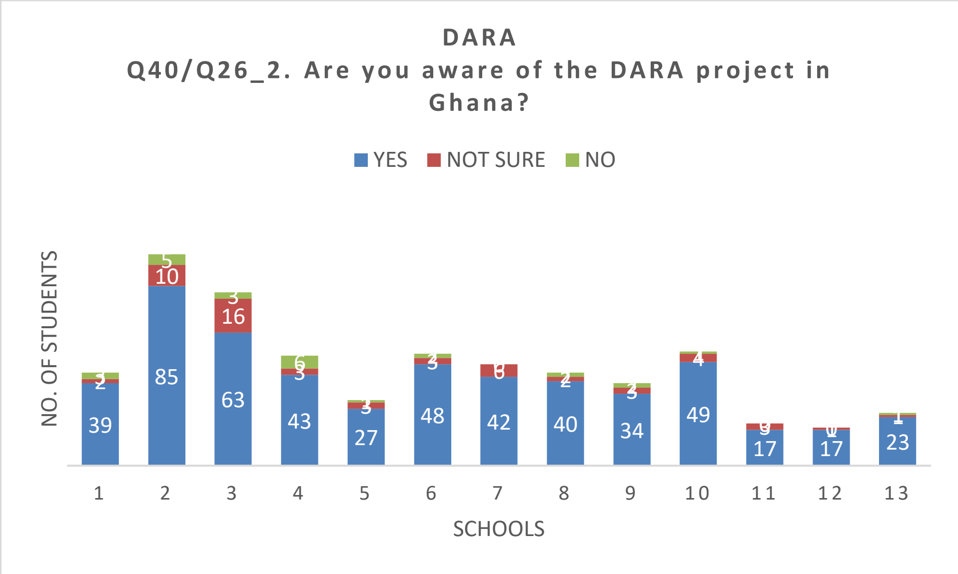
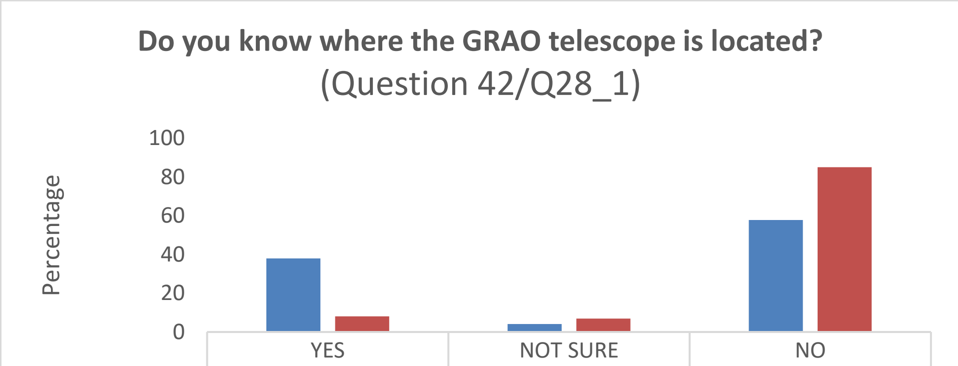


Figure 4.74: Comparison between DARA schools for question 40/Q26_2

From Figure 4.74, Kinbu SHTS (3) was an outlier school which was significantly different from the other schools with quite a number of student's responding ''not sure'' to the statement, hence the significant difference seen in the Kruskal Wallis test. Consensus in responding ''yes'' to the statement. Evenly spread between the schools. Kuntunse M/A Basic School 2 (7), Gbawe Islamic Basic School (11) and Unity Baptist Academy (12) responded ''no'' to the statement. Minor variations within the schools. Majority of the students in the schools were aware of the DARA project. An even spread among the schools was achieved.

Question 42/Q28_1: Do you know where the GRAO telescope is located?



	YES	NOT SURE	NO
%DARA	37.95986622	4.180602007	57.85953177
%NON-DARA	8.013937282	6.968641115	85.0174216

Figure 4.75: Descriptive statistics for question 42/Q28_1

From Figure 4.75, the results indicates that a larger majority of the DARA students know where the GRAO telescope is located more than the Non-DARA students.

Using the Mann-Whitney U test for question Q28_1, the Non-DARA group (N=292) had the higher mean rank (539.92) for the statement ''Do you know where the GRAO telescope is located?'' than the DARA group (N= 610) with mean rank (409.18). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =63242.000, p = .000 which is < .05) for the question ''Do you know where the GRAO telescope is located?''. The results indicate that the DARA group (students) know where the GRAO telescope is located more than the Non-DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''Do you know where the GRAO telescope is located?''. No statistically significant difference was found (H = 10.590, p = .158 which is > .05), indicating that the schools did not differ significantly from each other. Little Shepherd International School (N=40) had the highest mean rank (159.03), and Komenda College Practice Basic School (N=40) had the lowest mean rank (125.38). This shows that Little Shepherd International School responded ''no'' to the statement ''Do you know where the GRAO telescope is located?'' more than the other schools and Komenda College Practice Basic School responded ''yes'' to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Do you know where the GRAO telescope is located?''. A statistically significant difference was found (H = 206.143, p = .000 which is < .05), indicating that the schools differ significantly from each other. Presbyterian Boys' SHS-Legon (N=100) had the highest mean rank (404.12), and Katapor D/M Basic School (N=54) had the lowest mean rank (172.26). This shows that Presbyterian Boys' SHS-Legon answered ''no'' to the statement ''Do you know where the GRAO telescope is located?'' more than the other schools and Katapor D/M Basic School answered ''yes'' to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q28_1 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 206.143 > $H_{Non\text{-}DARA}$ = 10.590); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q28_1 (Do you know where the GRAO telescope is located?). A strong negative correlation was found *(r = -.114, p* < .01), indicating a significant relationship between the two variables. DARA students responded ''yes'' more than the Non-DARA students to the statement. In conclusion, the direction (negative), strength (strong), value (-.114) and **significance** level « .01) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q28_1. A strong negative correlation was found *(r* = -.281*, p* < .01), indicating a significant relationship between the two variables. DARA students responded ''yes'' more than the Non-DARA students to the statement. In conclusion, the direction (negative), strength (strong), value (-.281) and **significance** level « .01) of the correlation.

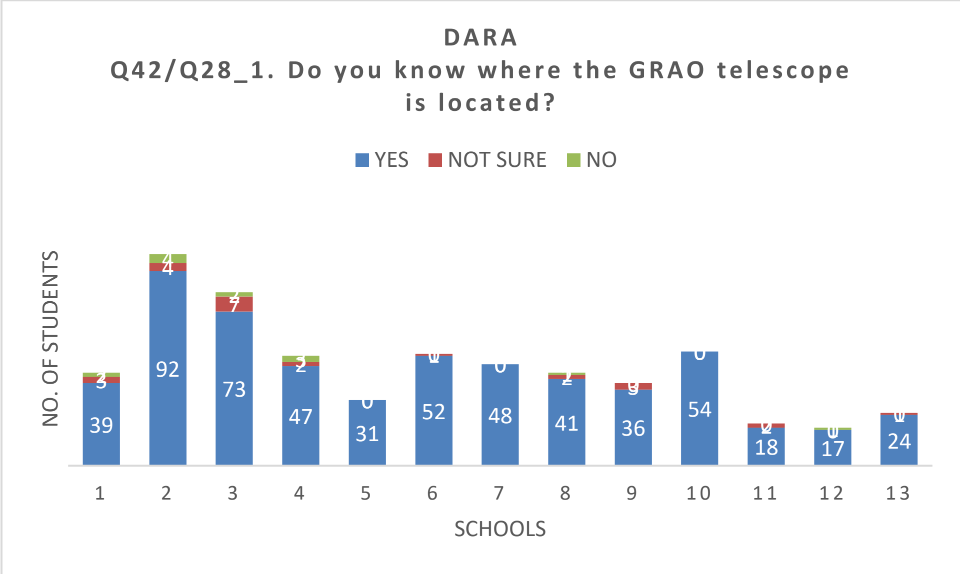


Figure 4.76: Comparison between DARA schools for question 42/Q28_1

From Figure 4.76 , GAEC Basic School (5), Kuntunse M/A Basic School 2 (7), and Katapor D/M Basic School (10) had majority of the students in their respective schools responding considerably more ‘’yes’’ to the statement than any of the other schools with no response to ‘’not sure’’ and ‘’no’’; hence, just a handful of the students in these schools know where the GRAO telescope is located and majority of the students in the other schools don’t know. A lot of variations within the schools in responding to the statement. The spread among the schools was not even. Tiwnikli International SHS (1) and Kinbu SHTS (3) were outliers schools that considerably responded less ‘’yes’’ to the statement.

Question 43/Q28_2: Have you gone on an excursion to the GRAO telescope?

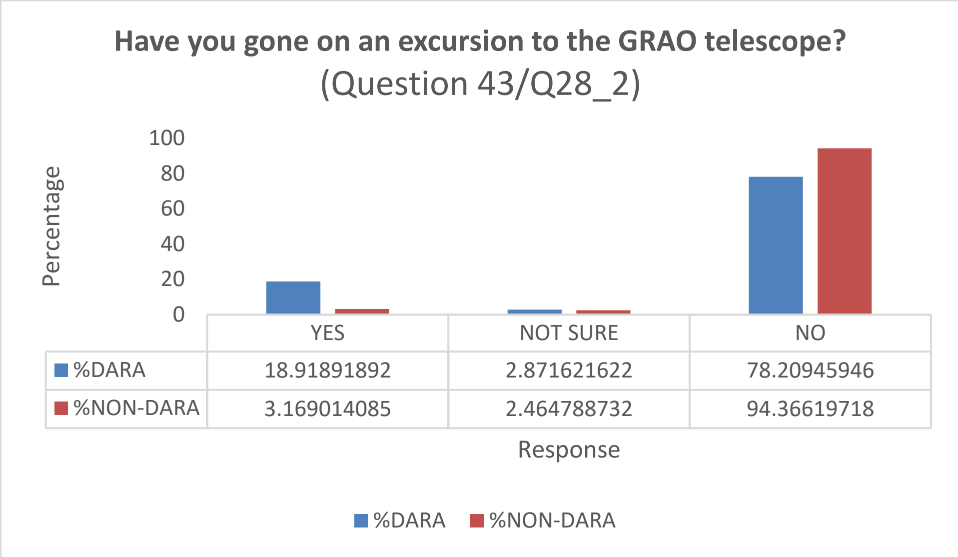


Figure 4.77: Descriptive statistics for question 43/Q28_**2**

From figure 4.77, the results indicates that more of the DARA students have gone on an excursion to the GRAO telescope more than the Non-DARA students. This was spread across the schools.

Using the Mann-Whitney U test for question Q28_2, the Non-DARA group (N=292) had the higher mean rank (493.55) for the statement ''Have you gone on an excursion to the GRAO telescope?'' than the DARA group (N= 610) with mean rank (431.37). From the test statistics, it can be concluded that there was a statistically significant difference between the DARA group and the Non-DARA group (U =76781.000, p = .000 which is < .05) for the question ''Have you gone on an excursion to the GRAO telescope?''. The results indicate that the DARA group (students) have gone on an excursion to the GRAO telescope more than the Non-DARA group.

A Kruskal-Wallis H test was conducted between the Non-DARA schools on how each school answered the question ''Have you gone on an excursion to the GRAO telescope?''. No statistically significant difference was found (H = 6.106, p = .527 which is > .05), indicating that the schools did not differ significantly from each other. Entsua Mensah Preparatory/JHS (N=23) had the highest mean rank (155.85), and Komenda M/A JHS B (N=38) had the lowest mean rank (140.01). This shows that Entsua Mensah

Preparatory/JHS answered ''no'' to the statement ''Have you gone on an excursion to the GRAO telescope?'' more than the other schools and Komenda M/A JHS B answered ''yes'' to the statement more than the other schools.

A Kruskal-Wallis H test was conducted between the DARA schools on how each school answered the question ''Have you gone on an excursion to the GRAO telescope?''. A statistically significant difference was found (H = 123.225, p = .000 which is < .05), indicating that the schools differ significantly from each other. Kwabenya Community SHS (N=52) had the highest mean rank (366.78), and Kuntunse M/A Basic School 1 (N=53) had the lowest mean rank (201.81). This shows that Kwabenya Community SHS responded ''no'' to the statement ''Have you gone on an excursion to the GRAO telescope?'' more than the other schools and Kuntunse M/A Basic School 1 answered ''yes'' to the statement more than the other schools.

Comparison between the DARA and Non-DARA schools for question Q28_2 indicates that the DARA schools have a higher Kruskal-Wallis H (H_{DARA} = 123.225 > $H_{Non\text{-}DARA}$ = 6.106); hence, there were more variations within the DARA schools than the Non-DARA schools in terms of how they answered this question.

A Pearson correlation coefficient was calculated for the relationship between subjects' school type and Q28_2 (Have you gone on an excursion to the GRAO telescope?). A weak negative correlation that was not significant was found *(r = -.038, p* > .05), indicating not a significant relationship between the two variables. DARA students responded ''yes'' more than the Non-DARA students to the statement. In conclusion, the direction (negative), strength (weak), value (-.038) and **significant** difference = .252 which is > .05, the p-value) of the correlation. A Spearman correlation coefficient was calculated for the relationship between subjects' school type and Q28_2. A strong negative correlation was found *(r* = -.164*, p* < .01), indicating a significant relationship between the two variables. DARA students responded ''yes'' more than the Non-DARA students to the statement. In conclusion, the table states the direction (negative), strength (strong), value (-.164), degrees of freedom (N), and significance level « .01) of the correlation.

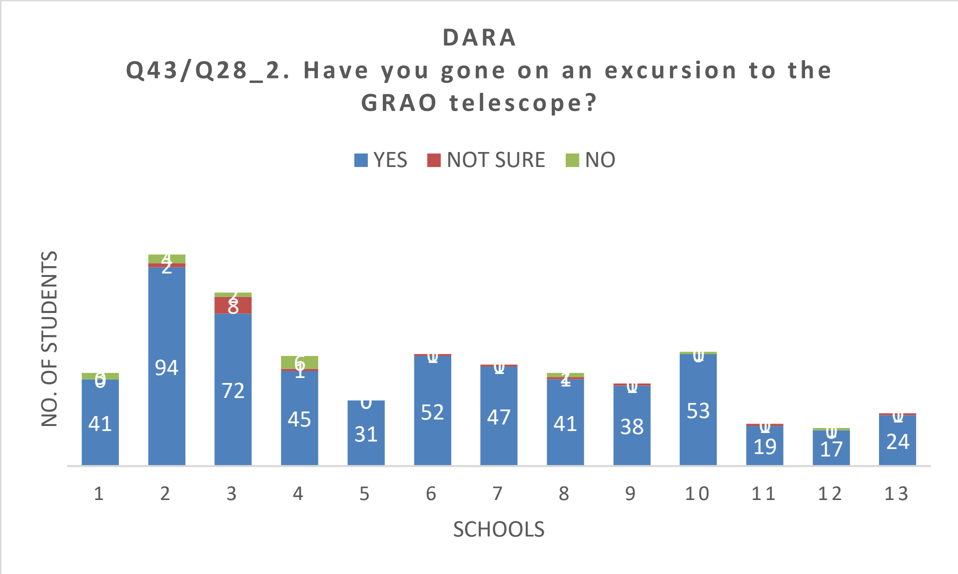


Figure 4.78: Comparison between DARA schools for question 43/Q28_2

Figure 4.78 shows that Kwabenya Community SHS (4) was an outlier school which responded less ‘’yes’’ to the statement and was significantly different from the other schools. Minor variations within the schools; hence, the significant difference shown in the Kruskal Wallis test. Spread not evenly distributed among the schools. Fair consensus on saying ‘’yes’’ to the statement, GAEC Basic School (5) had majority of the students saying they have gone on an excursion to the GRAO telescope with no ‘’not sure’’ and ‘’no’’ response to the statement.

4.5 Schools Responses to Questions that had Significant Kruskal Wallis H-Test

Figures 4.5 to 4.78 indicate the analyses of the variations in the Kruskal Wallis H-test results that were significant. The figures show the way the schools answered the questions that were significant from the Kruskal Wallis H-test results.

Table 4.1: Non-DARA schools with questions and outliers

Non-DARA schools with outliers	Questions with outliers	Number of outliers
Our Lady of Assumption R/C Basic School (8)	4_1, 4_5, 4_6, 4_7, 11_1, 14_1, 14_2, 14_3, 15_2, 15_3, 15_4, 15_5, 15_6, 15_7, 20_1, 25_1	16

Entsua Mensah Preparatory/JHS (7)	4_5, 4_6, 15_2, 26_1	4
Komenda College Practice Basic School (2)	4_1, 15_2, 25_1	3
St. Michael & All Angels Anglican JHS (5)	14_2, 15_2	2
Aldersgate Methodist Basic School (6)	25_1	1

From Table 4.1, majority of the outliers were found in Our Lady of Assumption R/C Basic School (8) and this is due to the way the students in the school responded to the questions. The students in this school think differently from the other schools. The Non-DARA outlier schools answered the questions such that the students agrees more to the questions than the other schools and also disagrees more to the questions than the other schools. These schools were likely outlier schools because their students and teachers had exposure to educational opportunities for example their proximity to the Komenda CoE (especially Komenda College Practice Basic School) and the University of Cape Coast (UCC), teachers in these schools stay updated through professional development programs and collaboration with these institutions (Komenda CoE, UCC) and other educators. Majority of the schools are mission schools with the exception of Entsua Mensah Preparatory/JHS (7); these schools inculcate Christian values and morals into their students. Some of the students' parents/families are teachers and workers at Komenda CoE, these students are able to get a lot of family support.

Table 4.2: DARA schools with questions and outliers

DARA schools with outliers	Questions with outliers	Number of outliers
GAEC Basic School (5)	4_5, 4_6, 14_1, 15_2, 15_3, 15_4, 15_5, 15_6, 15_7, 20_1, 25_1	11
Tiwnikli International SHS (1)	4_5, 4_9, 15_2, 28_1	4
Kinbu SHTS (3)	26_2, 28_1	2
Kuntunse M/A Basic School 2 (7)	14_3, 15_2	2
Kuntunse M/A Basic School 3 (8)	4_9, 14_1	2

Jeremite International School (13)	4_3, 25_1	2
Katapor D/M Basic School (10)	15_7, 20_1	2
Gbawe Islamic Basic School (11)	15_1, 15_5	2
Kwabenya Community SHS (4)	28_2	1
Unity Baptist Academy (12)	4_5	1

From Table 4.2, majority of the outliers were found in GAEC Basic School (5) and this is due to the way the students in the school responded to the questions. The students in this school think differently from the other schools in answering the questions. The DARA outlier schools answered the questions such that the students agree more to the questions than the other schools and also disagree more to the questions than the other schools. GAEC Basic School (5) and Kwabenya Community SHS (4) due to their proximity to the GSSTI makes the students in the school to have more engagement with Physics because it is one of the outreach schools and it is the first point of contact during commencement of the DARA programme in Ghana. These schools were likely outliers schools because their students and teachers had good infrastructure/facilities/resources, students and teachers had exposure to educational opportunities due to their proximity to the GSSTI, School of Nuclear and Applied Sciences (SNAS) and the University of Ghana (UG). Teachers in these schools stay updated through professional development programs and collaboration with these institutions, educators and have exposure to current pedagogical trends, teaching methodologies, and educational research due to the proximity to educational institutions, conferences, and professional networks. Some of the students' parents/families are teachers and workers at GSSTI, SNAS and UG, these students are able to get a lot of family support. Teachers in these schools are experienced, dedicated, qualified teachers and possess undergraduate (B.Ed, BSc.) and postgraduate degrees (MSc, MPhil. etc.) which makes them to teach well.

4.6 Analysis of Students Open Ended Questions

This section presents the analysis of the students open ended questions. The student's responses were coded into various thematic descriptions (categories), tallied, percentage of their responses were obtained and significance was determined.

Explanation of the analysis in the tables follows immediately. Typical responses that were coded for each thematic descriptions (categories) include the following :

Table 4.3: Typical students quotes for each thematic description

Description	Student Quotes
1. Knowledge Based (positive)	''Calculations, Know it very well, Useful ''
2. Knowledge Based (negative)	''No knowledge is acquired, No skills''
3. Long Term (positive)	''Achieve goals, Prepare for future''
4. Long Term (negative)	''Not to be important, No future''
5. Short Term	''Finish school, Pass, Get a job''
6. Resources	''Books, Internet, Video games, Apps''
7. People (personal contacts)	''My family, My siblings, Peers, Parents''
8. People (professional)	''Physicist, Astronomer, Engineer, Doctor''
9. Desire / Interest (positive)	''I like it, I enjoy it, my best subject''
10. Desire / Interest (negative)	''I hate science, I don't like it''
11. Nothing/no one/nobody	''Nothing/no one/nobody''
12. Nothing/no idea/no reason/can't tell/can't recall	''Nothing/no idea/no reason/can't tell/can't recall''
13. Undecided/not sure	''Undecided/not sure''
14. Science careers	''Statistician, Surveyor, Navigator''
15. Non-science careers	''Air hostess, Judge, Business man''
16. Practical/Technical careers	''Plumber, Mechanic, Contractor, Artist''
17. Educational careers	''Teacher, Educator''
18. Physicist	''Physicist, Astrophysicist''
19. Engineering/Engineer	''Civil, Mechanical, Electrical, Aerospace''
20. Medical careers	''Doctor, Nurse, Midwife, Dentist''

21. Advice	''by advising me''
22. I have not been there	'' I have not been there''
23. Correct/right	''Ghana Radio Astronomy Observatory''
24. Incorrect/wrong	''Ghana Radio Astronomy Observation''

Table 4.3: Non-DARA/DARA students' response to open ended question 10 (From question 9: My teacher was my main influence in liking Physics, what else influence you?)

Description	Non-DARA Tally	Non-DARA %	DARA Tally	DARA %	Significance
1. Knowledge Based (positive)	121	40.1	233	36.5	0.033
2. Long Term	45	14.9	63	9.9	0.007
3. Short Term	5	1.7	6	0.9	0.155
4. Resources	23	7.6	25	3.9	0.008
5. People (personal contacts)	0	0.0	204	32.0	<0.001
6. People (professionals)	0	0.0	34	5.3	<0.001
7. Desire / Interest (positive)	12	4.0	30	4.7	0.121
8. Desire / Interest (negative)	2	0.7	10	1.6	0.141
9. Nothing/no one/nobody	7	2.3	33	5.2	0.017
Total	**302**	100.0	**638**	100.0	

From response rates in Table 4.3, the most popular response category was the Knowledge Based (positive) for both DARA students and Non-DARA, and also People (personal contacts) for DARA students. There was no significant difference between the Non-DARA students and the DARA students for the short term, Desire / Interest (positive), Desire / Interest (negative) categories for whoever influence them in liking Physics.

Non-DARA students responded higher (40.1%) for the knowledge based (positive) category than the DARA students (36.5%). This shows that Non-DARA students have more knowledge based (positive) influence from their teachers in liking Physics than the DARA students. Non-DARA students responded higher (14.9%) for the long term benefits of Physics category than the DARA students (9.9%). This shows that Non-DARA students have more long term influence in liking Physics than the DARA students. Non-DARA students responded higher (7.6%) for the resource category than the DARA students (3.9%). This shows that Non-DARA students have more resources that influence them in liking Physics than the DARA students. DARA students responded higher (32.0%) for the People (personal contacts) category than the Non-DARA students (0.0%). This shows that DARA students have more People (personal contacts)) who influence them in liking Physics than the Non-DARA students. DARA students responded higher (5.3%) for the People (professionals) category than the Non-DARA students (0.0%). This shows that DARA students have more People (professionals) who influence them in liking Physics than the Non-DARA students. DARA students responded higher (5.2%) for the nothing/no one/nobody category than the Non-DARA students (2.3%). This shows that DARA students had more response that said nothing/no one/nobody influenced them in liking physics than the Non-DARA students.

DARA students responded higher (32.0%) for the people (personal contacts) category than the Non-DARA students (0.0%). This shows that DARA students have more people (personal contacts) who influence them in liking Physics than the Non-DARA students, (more significant) and also DARA students responded higher (5.3%) for the people (professionals) category than the Non-DARA students (0.0%). This shows that DARA students have more people (professionals) who influence them in liking Physics than the Non-DARA students (more significant). The Knowledge Based (positive), Long Term, Resources, People (contact), People (professionals) and Nothing/nobody categories were significant and the other categories were not significant. This shows that there was significant difference between DARA and Non-DARA students in these categories in terms of what influences them to enjoy/like Physics.

Table 4.4: Question 10 (From question 9: My teacher was my main influence in liking Physics, what else influence you?)

Schooltype	**0**	**1**	**Total**	**% Response**
Non-DARA	22	**270**	292	**92.5**
DARA	72	**538**	610	**88.2**
Total	94	808	902	180.7

Table 4.4 shows that 270 (92.5%) Non-DARA students and 538 (88.2%) DARA students responded to the question above which gave a significance of 0.01 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.5: Non-DARA/DARA students' response to open ended question 15 (Give reasons for your answer in question 14: Is it important to study Physics at the Colleges of Education?)

Description	Non-DARA Tally	Non-DARA %	DARA Tally	DARA %	Significance
1. Knowledge Based (positive)	170	60.1	294	52.8	0.008
2. Long Term	61	21.6	167	30.0	0.002
3. Short Term	3	1.1	7	1.3	0.260
4. Resources	1	0.4	14	2.5	0.015
5. People (professionals)	8	2.8	10	1.8	0.119
6. Desire / Interest (positive)	6	2.1	9	1.6	0.183
7. Desire / Interest (negative)	34	12.0	56	10.1	0.063
Total	**283**	100.0	**557**	100.0	

From response rates in Table 4.5, the most popular response category was the Knowledge Based (positive) for both DARA and Non-DARA students. Non-DARA students responded higher (60.1%) for the Knowledge Based category than the DARA students (52.8%). This shows that Non-DARA students have more Knowledge Based reasons to study Physics at the Colleges of Education (CoE) than the DARA students. DARA students responded higher (1.3%) for the long term category than the Non-DARA students (1.1%). This shows that DARA students have more long term reasons to study Physics at the CoE than the Non-DARA students. DARA students responded higher (2.5%) for the resources category than the Non-DARA students (0.4%). This shows that DARA students have more resource reasons to study Physics at the CoE than the Non-DARA students. These categories had significant difference for the reasons to study Physics at the CoE. There was no significant difference between the Non-DARA students and the DARA students for the short term, People (personal contacts), People (professionals), Desire / Interest (positive), Desire / Interest (negative) categories for the reasons to study Physics at the CoE.

The Knowledge Based (positive), Long term and Resources categories were significant and the other categories were not. Majority of these students were thinking about College and know the importance of studying Physics at the CoE. This shows that there was significant difference between DARA and Non-DARA students in these categories in terms of the importance for them to study Physics at the Colleges of Education.

Table 4.6: Question 15 (Give reasons for your answer in question 14: Is it important to study Physics at the Colleges of Education?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
Non-DARA	17	**275**	292	**94.2**
DARA	102	**508**	610	**83.3**
Total	119	783	902	**177.5**

Table 4.6 shows that 275 (94.2%) Non-DARA students and 508 (83.3%) DARA students responded to the question above which gave a significance of <0.001 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.7: Non-DARA/DARA students' response to open ended question 17 (Give reasons for your answer in question 16: Is it important to study Physics at the Universities?)

Description	**Non-DARA Tally**	**Non-DARA %**	**DARA Tally**	**DARA %**	**Significance**
1. Knowledge Based (positive)	105	50.7	283	45.8	0.030
2. Knowledge Based (negative)	3	1.4	19	3.1	0.099
3. Long Term (positive)	62	30.0	169	27.3	0.054
4. Long Term (negative)	0	0.0	6	1.0	0.176
5. Short Term	10	4.8	34	5.5	0.136
6. Resources	0	0.0	8	1.3	0.098
7. People (professionals)	5	2.4	24	3.9	0.115
8. Desire / Interest (positive)	5	2.4	17	2.8	0.195
9. Desire / Interest (negative)	17	8.2	58	9.4	0.100
Total	**207**	100.0	**618**	100.0	

From response rates in Table 4.7, the most popular response category was the Knowledge Based (positive) and Long Term (positive) for both DARA and Non-DARA students. There was no significant difference between the Non-DARA students and the DARA students for the Knowledge Based (negative), Long Term (positive), Long Term (negative), Short Term, Resources, People (professionals), Desire / Interest (positive) and Desire / Interest (negative) categories for reasons to study Physics at the Universities. Non-DARA students responded higher (50.7%) for the Knowledge Based (positive) category than the DARA students (45.8%). This shows that Non-DARA students have more Knowledge Based (positive) reasons to study Physics at the Universities than the DARA students. The DARA students answered these question more than the Non-DARA students, hence the DARA students gave more reasons why it is important to study Physics at the Universities than the Non-DARA students. There was significant difference for the Knowledge Based (positive) category between Non-DARA and DARA students for reasons to study Physics at the Universities.

Table 4.8: Question 17 (Give reasons for your answer in question 16: Is it important to study Physics at the Universities?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
Non-DARA	29	**263**	292	**90.1**
DARA	100	**510**	610	**83.6**
Total	129	773	902	**173.7**

Table 4.8 shows that 263 (90.1%) Non-DARA students and 510 (83.6%) DARA students responded to the question above which gave a significance of 0.00 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.9: Non-DARA/DARA students response to open ended question 18 (What did your teacher do to help you know the relevance of Physics?)

Description	Non-DARA Tally	Non-DARA %	DARA Tally	DARA %	Significance
1. Knowledge Based (positive)	205	65.7	330	56.4	0.001
2. Knowledge Based (negative)	1	0.3	0	0.0	0.348
3. Long Term (positive)	61	19.6	100	17.1	0.047
4. Long Term (negative)	0	0.0	3	0.5	0.277
5. Short Term	15	4.8	34	5.8	0.103
6. Resources	11	3.5	68	11.6	<0.001
7. People (professionals)	5	1.6	15	2.6	0.129
8. Desire / Interest (positive)	11	3.5	5	0.9	0.004
9. Desire / Interest (negative)	3	1.0	28	4.8	0.001
10. Nothing/can't tell/can't recall	0	0.0	2	0.3	0.425
Total	**312**	100.0	**585**	100.0	

From response rates in Table 4.9, the most popular response category was the Knowledge Based (positive) for both DARA and Non-DARA students. Non-DARA students responded higher (70.2%) for the Knowledge Based (positive) category than the DARA students (56.4%). This shows that Non-DARA students have more Knowledge Based (positive) for what their teacher did to help them know the relevance of Physics than the DARA students. DARA students responded higher (11.6%) for Resources category than the Non-DARA students (3.5%). This shows that the DARA students have more Resources for what their teacher did to help them know the relevance of Physics than the Non-DARA students. Non-DARA students responded higher (3.5%) Desire / Interest (positive) category than the DARA students (0.9%). This shows that the Non-DARA students have more Desire / Interest (positive) for what their teacher did to help them know the relevance of Physics than the DARA students. DARA students responded higher (4.8%) for Desire / Interest (negative) category than the Non-DARA students (1.0%). This shows that the DARA students have more Desire / Interest (negative) for what their teacher did to help them know the relevance of Physics than the Non-DARA students.

There was no significant difference between the Non-DARA students and the DARA students for the Knowledge Based (negative), Long Term (positive), Long Term (negative), Short Term, People (personal contacts), People (professionals), Nothing/can't tell/can't recall categories for what their teacher did to help them know the relevance of Physics. The Knowledge Based (positive), Resources, Desire / Interest (positive) and Desire / Interest (negative) categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA in these categories in terms of what their teacher did to help them know the relevance of Physics.

Table 4.10: Question 18 (What did your teacher do to help you know the relevance of Physics?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
Non-DARA	31	**261**	292	**89.4**
DARA	120	**490**	610	**80.3**
Total	151	751	902	**169.7**

Table 4.10 shows that 261 (89.4%) Non-DARA students and 490 (80.3%) DARA students responded to the question above which gave a significance of 0.00 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.11: Non-DARA/DARA students response to open ended question 29 (Give any other reasons for choosing to study Physics).

Description	Non-DARA Tally	Non-DARA %	DARA Tally	DARA %	Significance
1. Knowledge Based (positive)	102	34.0	191	38.2	0.059
2. Long Term (positive)	115	38.3	140	28.0	0.000
3. Short Term	12	4.0	22	4.4	0.144
4. Resources	2	0.7	0	0.0	0.121
5. People (professionals)	10	3.3	14	2.8	0.129
6. Desire / Interest (positive)	40	13.3	90	18.0	0.047
7. Desire / Interest (negative)	11	3.7	11	2.2	0.057
8. Nothing /no reason	8	2.7	29	5.8	0.033
9. Undecided	0	0.0	3	0.6	0.277
Total	**300**	100.0	**500**	100.0	

From response rates in Table 4.11, the most popular response category was the Knowledge Based (positive) for the DARA students and Long Term (positive) for the Non-DARA students. There was no significant difference between the Non-DARA students and the DARA students for the Knowledge Based (positive), Short Term, Resources, People (professionals), Desire / Interest (positive), Desire / Interest (negative), and Undecided categories for any other reasons they choose to study Physics. Non-DARA students responded higher (38.3%) for the Long Term (positive) category than the DARA students (28.0%). This shows that Non-DARA students have more Knowledge Based (positive) reasons to choose to study Physics than the DARA students. DARA students responded higher (5.8%) for the nothing /no reason category than the Non-DARA students (2.7%). This shows that the DARA students have more nothing /no reason why they want to choose to study Physics than the DARA students.

The DARA students answered these question more than the Non-DARA students; hence, the DARA students gave more other reasons for choosing to study Physics than the Non-DARA students. The Long Term (positive) and nothing /no reason categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA in these categories in terms of any other reasons they choose to study Physics.

Table 4.12: Question 29 (Give any other reasons for choosing to study Physics).

Schooltype	0.00	1.00	Total	% Response
Non-DARA	18	**274**	292	**93.8**
DARA	137	**473**	610	**77.5**
TOTAL	155	747	902	**171.4**

Table 4.12 shows that 274 (93.8%) Non-DARA students and 473 (77.5%) DARA students responded to the question above which gave a significance of <0.001 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.13: Non-DARA/DARA students' response to open ended question 30 (State the main reasons in question 26: Will you choose to study Physics at the SHS?).

Description	Non-DARA Tally	Non-DARA %	DARA Tally	DARA %	Significance
1. Knowledge Based (positive)	105	34.2	182	33.6	0.059
2. Knowledge Based (negative)	0	0.0	6	1.1	0.067
3. Long Term (positive)	73	23.8	131	24.2	<0.001
4. Long Term (negative)	0	0.0	3	0.6	0.259
5. Short Term	12	3.9	18	3.3	0.136
6. Resources	0	0.0	2	0.4	0.407
7. People (professionals)	43	14.0	16	3.0	<0.001
8. Desire / Interest (positive)	31	10.1	91	16.8	0.002
9. Desire / Interest (negative)	33	10.7	73	13.5	0.045
10. Nothing /no reason	9	2.9	7	1.3	0.052
11. Undecided	1	0.3	12	2.2	0.021
Total	**307**	100.0	**541**	100.0	

From response rates in Table 4.13, the most popular response category was the Knowledge Based (positive) for both DARA and Non-DARA students. There was no significant difference between the Non-DARA students and the DARA students for the Knowledge Based (positive), Knowledge Based (negative), Long Term (negative), Short Term, Resources, Desire / Interest (negative) and Nothing /no reason/no idea categories for reasons why they choose to study Physics at the SHS.

DARA students responded higher (24.2%) for Long Term (positive) category than the Non-DARA students (23.8%). This shows that DARA students have more Knowledge Based (positive) for reasons why they choose to study Physics at the SHS than the Non-DARA students. Non-DARA students responded higher (14.0%) for People (professionals) category than the DARA students (3.0%). This shows that the Non-DARA students have more People (professionals) for reasons why they choose to study Physics at the SHS than the DARA students. DARA students responded higher (16.8%) for Desire / Interest (positive) category than the Non-DARA students (10.1%). This shows that DARA students have more Desire / Interest (positive) for reasons why they choose to study Physics at the SHS than the Non-DARA students. DARA students responded higher (2.2%) for Undecided category than the Non-DARA students (0.3%). This shows that DARA students have more Undecided for reasons why they choose to study Physics at the SHS than the Non-DARA students.

Non-DARA students responded higher (14.0%) for People (professionals) category than the DARA students (3.0%). This shows that the Non-DARA students have more People (professionals) for reasons why they choose to study Physics at the SHS than the DARA students. The DARA students answered these question more than the Non-DARA students hence the DARA students gave more main reasons why they will choose to study Physics at the SHS than the Non-DARA students. The Long Term (positive), People (professionals), Desire / Interest (positive) and Undecided categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA in these categories in terms of reasons why the students will choose to study Physics at the SHS.

Table 4.14: Question 30 (State the main reasons in question 26: Will you choose to study Physics at the SHS?).

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
Non-DARA	26	**266**	292	**91.1**
DARA	113	**497**	610	**81.5**
Total	139	763	902	**172.6**

Table 4.14 shows that 266 (91.1%) Non-DARA students and 497 (81.5%) DARA students responded to the question above which gave a significance of <0.001 and this shows

that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.15: Non-DARA/DARA students' response to open ended question 31 (State the main reasons in question 27: Will you choose to study Physics at the Colleges of Education?)

Description	**Non-DARA Tally**	**Non-DARA %**	**DARA Tally**	**DARA %**	**Significance**
1. Knowledge Based (positive)	96	34.7	165	34.8	0.063
2. Knowledge Based (negative)	0	0.0	4	0.8	0.158
3. Long Term (positive)	81	29.2	96	20.3	0.001
4. Long Term (negative)	3	1.1	2	0.4	0.199
5. Short Term	10	3.6	20	4.2	0.143
6. People (professionals)	35	12.6	18	3.8	<0.001
7. Desire / Interest (positive)	18	6.5	44	9.3	0.046
8. Desire / Interest (negative)	21	7.6	76	16.0	0.000
9. Nothing /no reason	8	2.9	21	4.4	0.093
10. Undecided	5	1.8	28	5.9	0.004
Total	**277**	100.0	**474**	100.0	

From response rates in Table 4.15, the most popular response category was the Knowledge Based (positive) for both DARA and Non-DARA students. Non-DARA students responded higher (29.2%) for Long Term (positive) category than the DARA students (20.3%). This shows that the Non-DARA students have more Long Term (positive) for reasons why they choose to study Physics at the CoE than the DARA students. Non-DARA students responded higher (12.6%) for People (professionals) category than the DARA students (3.8%). This shows that the Non-DARA students have more People (professionals) for reasons why they choose to study Physics at the CoE than the DARA students. DARA students responded higher (16.0%) for Desire / Interest (negative) category than the Non-DARA students (7.6%). This shows that the DARA students have more Desire / Interest (negative) for reasons why they choose to study Physics at the CoE than the Non-DARA students. DARA students responded higher (5.9%) for Undecided category than the Non-DARA students (1.8%). This shows that the DARA students were more undecided for reasons why they choose to study Physics at the CoE than the Non-DARA students.

The Long Term (positive), People (professionals), Desire / Interest (positive) and Undecided categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA in these categories in terms of reasons why the students will choose to study Physics at the CoE. There was no significant difference between the Non-DARA students and the DARA students for the Knowledge Based (positive), Knowledge Based (negative), Long Term (negative), Short Term, Desire / Interest (positive) and Nothing /no reason/no idea categories for reasons why they choose to study Physics at the CoE. The DARA students answered these question more than the Non-DARA students; hence, the DARA students gave more main reasons why they will choose to study Physics at the CoE than the DARA students.

Table 4.16: Question 31 (State the main reasons in question 27: Will you choose to study Physics at the Colleges of Education?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
NON-DARA	35	**257**	292	**88.0**
DARA	166	**444**	610	**72.8**
TOTAL	201	701	902	**160.8**

Table 4.16 shows that 257 (88.0%) Non-DARA students and 444 (72.8%) DARA students responded to the question above which gave a significance of <0.001 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.17: Non-DARA students' response to open ended question 32 (State the main reasons in question 28: Will you choose to study Physics at the Universities?)

Description	Non-DARA Tally	Non-DARA %	DARA Tally	DARA %	Significance
1. Knowledge Based (positive)	73	25.3	151	32.8	0.006
2. Knowledge Based (negative)	2	0.7	9	2.0	0.102
3. Long Term (positive)	92	31.9	121	26.2	0.016
4. Long Term (negative)	2	0.7	13	2.8	0.027
5. Short Term	11	3.8	11	2.4	0.092
6. Resources	0	0.0	1	0.2	0.615
7. People (professionals)	41	14.2	21	4.6	<0.001
8. Desire / Interest (positive)	24	8.3	30	6.5	0.073
9. Desire / Interest (negative)	26	9.0	61	13.2	0.020
10. Nothing /no reason	13	4.5	19	4.1	0.141
11. Undecided	4	1.4	24	5.2	0.003
Total	**288**	100.0	**461**	100.0	

From response rates in Table 4.17, the most popular response category was the Knowledge Based (positive) for DARA students and Long Term (negative) for Non-DARA students. There was no significant difference between the Non-DARA students and the DARA students for the Knowledge Based (negative), Resources, Short Term, Desire / Interest (positive) and nothing /no reason/no idea/not applicable categories for what their teacher did to help them know the relevance of Physics.

DARA students responded higher (32.8%) for Knowledge Based (positive) category than the Non-DARA students (25.3%). This shows that the DARA students have more Knowledge Based (positive) for reasons why they choose to study Physics at the Universities than the Non-DARA students. Non-DARA students responded higher (31.9%) for Long Term (positive) category than the DARA students (26.2%). This shows that the Non-DARA students have more Long Term (positive) for reasons why they choose to study Physics at the Universities than the DARA students. DARA students responded higher (2.8%) for Long Term (negative) category than the Non-DARA students (0.7%). This shows that the DARA students have more Long Term (negative) for reasons why they choose to study Physics at the Universities than the Non-DARA students. Non-

DARA students responded higher (14.2%) for the People (professionals) category than the DARA students (4.6%). This shows that Non-DARA students have more People (professionals) for reasons why they choose to study Physics at the Universities than the DARA students. DARA students responded higher (13.2%) Desire / Interest (negative) category than the Non-DARA students (9.0%). This shows that the DARA students have more Desire / Interest (negative) for reasons why they choose to study Physics at the Universities than the Non-DARA students. DARA students responded higher (5.2%) Undecided category than the Non-DARA students (1.4%). This shows that the DARA students have more Undecided reasons why they choose to study Physics at the Universities than the Non-DARA students.

The Knowledge Based (positive), Long Term (positive), Long Term (negative), People (professionals), Desire / Interest (negative) and Undecided categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA in these categories in terms of reasons why the students will choose to study Physics at the Universities. The DARA students answered these question more than the Non-DARA students hence the DARA students gave more main reasons why they will choose to study Physics at the Universities than the Non-DARA students.

Table 4.18: Question 32 (State the main reasons in question 28: Will you choose to study Physics at the Universities?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
NON-DARA	34	**258**	292	**88.4**
DARA	178	**432**	610	**70.8**
TOTAL	212	690	902	**159.2**

Table 4.18 shows that 258 (88.4%) Non-DARA students and 432 (70.8%) DARA students responded to the question above which gave a significance of <0.001 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.19: Non-DARA/DARA students' response to open ended question 34 (Give your reasons to question 33 above: I'm planning a career that uses Physics.)

Description	**Non-DARA Tally**	**Non-DARA %**	**DARA Tally**	**DARA %**	**Significance**
1. Knowledge Based (positive)	48	20.4	86	19.8	0.079
2. Knowledge Based (negative)	1	0.4	1	0.2	0.456
3. Long Term (positive)	56	23.8	79	18.2	0.018
4. Long Term (negative)	8	3.4	11	2.5	0.151
5. Short Term	20	8.5	43	9.9	0.095
6. Resources	0	0.0	3	0.7	0.273
7. People (professionals)	41	17.4	72	16.6	0.081
8. Desire / Interest (positive)	15	6.4	45	10.3	0.026
9. Desire / Interest (negative)	40	17.0	70	16.1	0.082
10. Nothing /no reason/no idea	3	1.3	16	3.7	0.040
11. Undecided	3	1.3	9	2.1	0.195
Total	**235**	100.0	**435**	100.0	

From response rates in Table 4.19, the most popular response category was the Knowledge Based (positive) for DARA students and Long Term (positive) for Non-DARA students. Non-DARA students responded higher (20.4%) for Long Term (positive) category than the DARA students (19.8%). This shows that the Non-DARA students have more Long Term (positive) reasons of planning a career that uses Physics than the DARA students. DARA students responded higher (10.3%) for the Desire / Interest (positive) category than the Non-DARA students (6.4%). This shows that DARA students have more Desire / Interest (positive) reasons of planning a career that uses Physics than the Non-DARA students. DARA students responded higher (3.7%) for the Nothing /no reason/no idea category than the Non-DARA students (1.3%). This shows that DARA students have more Nothing /no reason/no idea reasons of planning a career that uses Physics than the Non-DARA students.

There was no significant difference between the Non-DARA students and the DARA students for the Knowledge Based (positive), Knowledge Based (negative), Long Term (negative), Short Term, Resources, People (professionals), Desire / Interest (negative), and undecided categories for reasons of planning a career that uses Physics. The Long

Term (positive), Desire / Interest (positive) and nothing /no reason/no idea categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA students in these categories in terms of careers that they are planning that uses Physics.

Table 4.20: Question 34 (Give your reasons to question 33 above: I'm planning a career that uses Physics.)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
Non-DARA	55	**237**	292	**81.2**
DARA	208	**402**	610	**65.9**
Total	263	639	902	**147.1**

Table 4.20 shows that 237 (81.2%) Non-DARA students and 402 (65.9%) DARA students responded to the question above which gave a significance of <0.001 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.21: Non-DARA/DARA students' response to open ended question 35a (What careers are you considering?)

Description	**Non-DARA Tally**	**Non-DARA %**	**DARA Tally**	**DARA %**	**Significance**
1. Science careers	49	17.0	77	13.6	0.034
2. Non-science careers	57	19.8	112	19.8	0.072
3. Practical /Technical careers	19	6.6	54	9.6	0.036
4. Educational careers	43	14.9	26	4.6	<0.001
5. Physicist	0	0.0	26	4.6	<0.001
6. Engineering/Engineer	27	9.4	137	24.2	<0.001
7. Medical careers	90	31.3	115	20.4	0.000
8. Nothing /no reason	1	0.3	9	1.6	0.082
9. Undecided	2	0.7	9	1.6	0.024
Total	**288**	100.0	**565**	100.0	

From response rates in Table 4.21, the rank order of careers for Non-DARA students were first: Medical careers, second: Non-science careers and third: Science careers. In addition, the rank order of careers for DARA students were first: Engineering/Engineer, second: Medical careers and third: Non-science careers. There was no significant difference between the Non-DARA students and the DARA students for Non-Science careers and nothing /no reason categories for careers they are considering. Non-DARA students responded higher (17.0%) for Science careers category than the DARA students (13.6%). This shows that the Non-DARA students are considering more Science careers than the DARA students**.** DARA students responded higher (9.6%) for Practical /Technical careers category than the Non-DARA students (6.6%), this shows that the DARA students are considering more Practical /Technical careers than the Non-DARA students**.** Non-DARA students responded higher (14.9%) for the Educational careers category than the DARA students (4.6%). This shows that Non-DARA students are considering more Educational careers than the DARA students. DARA students responded higher (4.6%) to become Physicists than the Non-DARA students (0.0%). This shows that DARA students are considering to become Physicists more than the Non-DARA students. This was a very significant difference. DARA students responded higher (24.2%) to become Engineers than the Non-DARA students (9.4%). This shows that DARA students are considering to become Engineers more than the Non-DARA students.

Non-DARA students responded higher (31.3%) for Medical careers category than the DARA students (20.4%). This shows that Non-DARA students are considering more Medical careers than the DARA students. DARA students responded higher (1.6%) for Undecided category than the Non-DARA students (0.7%), this shows that the DARA students were more undecided than the Non-DARA students for careers they are considering. The Science careers, Practical /Technical careers, Educational careers, Physicist, Engineering/Engineer, Medical careers and undecided categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA students in these categories in terms of the careers they were considering.

Table 4.22: Question 35 (What careers are you considering and why?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
NON-DARA	38	**254**	292	**87.0**
DARA	159	**451**	610	**73.9**
Total	197	705	902	**160.9**

Table 4.22 shows that 254 (87.0%) Non-DARA students and 451 (73.9%) DARA students responded to the question above which gave a significance of <0.001 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.23: Non-DARA students' response to open ended question 35b (why are you considering these careers?)

Description	Non-DARA Tally	Non-DARA %	DARA Tally	DARA %	Significance
1. Knowledge Based (positive)	71	35.0	92	28.3	0.021
2. Long Term (positive)	61	30.0	83	25.5	0.042
3. Short Term	38	18.7	55	16.9	0.081
4. Resources	0	0.0	2	0.6	0.378
5. Desire / Interest (positive)	31	15.3	90	27.7	0.000
6. Desire / Interest (negative)	2	1.0	3	0.9	0.346
Total	**203**	100.0	**325**	100.0	

From response rates in Table 4.23, the rank order of why the students were considering careers mentioned for Non-DARA students were first: Knowledge Based (positive), second: Long Term (positive) and third: Short Term. In addition, the rank order of careers for DARA students were first: Knowledge Based (positive), second: Desire / Interest (positive) and third: Long Term (positive). Non-DARA students responded higher (35.0%) for the Knowledge Based (positive) category than the DARA students (28.3%), this shows that Non-DARA students have more Knowledge Based (positive) reasons of considering careers than the DARA students. Non-DARA students responded higher (30.0%) for the Long Term (positive) category than the DARA students (25.5%). This shows that Non-DARA students have more Long Term (positive) reasons of considering careers than the DARA students. DARA students responded higher (27.7%) for the Desire / Interest (positive) category than the Non-DARA students (15.3%). This shows that DARA students have more Desire / Interest (positive) for the reasons of considering careers than the Non-DARA students. There was no significant difference between the Non-DARA students and the DARA students for the Short Term, Resources and Desire / Interest (negative) categories for why they are considering these careers.

The Knowledge Based (positive), Long Term (positive) and Desire / Interest (positive) categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA students in these categories in terms of why they were considering these careers. The response rate for this question is the same as in Table 4.22.

Table 4.24: Non-DARA/DARA students response to open ended question 36 (List as many careers you think uses Physics.)

Description	Non-DARA Tally	Non-DARA %	DARA Tally	DARA %	Significance
1. Science careers	126	14.6	260	20.1	0.06
2. Non-science careers	157	18.2	134	10.3	<0.001
3. Practical /Technical careers	78	9.0	47	3.6	<0.001
4. Educational careers	91	10.5	94	7.3	<0.001
5. Physicist	25	2.9	167	12.9	<0.001
6. Engineering/Engineer	128	14.8	347	26.8	<0.001
7. Medical careers	259	30.0	245	18.9	<0.001
8. Nothing /no idea/no reason	0	0.0	2	0.2	0.46
Total	**864**	100.0	**1296**	100.0	

From response rates in Table 4.24, the rank order of careers for Non-DARA students were first: Medical careers, second: Non-science careers and third: Engineering/Engineer. In addition, the rank order of careers for DARA students were first: Engineering/Engineer, second: Science careers and third: Medical careers. There was no significant difference between the Non-DARA students and the DARA students for the science careers, nothing/no idea/I don't know category to list as many careers they think uses Physics. Very interesting and significant differences were found between Non-DARA and DARA students as the students listed as many careers they think uses Physics. Non-DARA students responded higher (88.7%) for the medical careers category than the DARA students (40.2%). This shows that Non-DARA students listed as many careers that uses Physics under the medical careers category than the DARA students. Non-DARA students responded higher (53.8%) for the non-science careers category than the DARA students (22.0%). This shows that Non-DARA students listed as many careers that uses Physics under the non-science careers category than the DARA students. DARA students responded higher (56.9%) for the engineering/engineer category than the Non-DARA students (43.8%). This shows that DARA students listed as many careers that uses Physics under the engineering/engineer category than the Non-DARA students. Non-DARA students responded higher (31.2%) for the educational careers category than the DARA students (15.4%). This shows that Non-DARA students listed as many careers that uses Physics under the educational careers category than the DARA students. Non-DARA students responded higher (26.7%) for the practical/technical careers category than the DARA students (7.7%). This shows that Non-DARA students listed as many careers that uses Physics under the practical/technical careers category than the DARA students. DARA students responded higher (27.4%) for the physicist category than the Non-DARA students (8.6%). This shows that DARA students listed as many careers that uses Physics under the physicist category than the Non-DARA students.

The Non-Science careers, Practical /Technical careers, Educational careers, Physicist, Engineering/Engineer and Medical careers categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA students in these categories in terms of listing many careers they think uses Physics.

Table 4.25:Question 36 (List as many careers you think uses Physics.)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
NON-DARA	38	**254**	292	**87.0**
DARA	159	**451**	610	**73.9**
Total	197	705	902	**160.9**

Table 4.25 shows that 254 (87.0%) Non-DARA students and 451 (73.9%) DARA students responded to the question above which gave a significance of <0.001 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.26: Non-DARA/DARA students response to open ended question 37 (What did your teacher do to inform or inspire you about careers in Physics?)

Description	Non-DARA Tally	Non-DARA %	DARA Tally	DARA %	Significance
1. Knowledge Based (positive)	150	59.3	290	54.3	0.026
2. Long Term (positive)	57	22.5	83	15.5	0.005
3. Short Term	21	8.3	49	9.2	0.099
4. Resources	1	0.4	4	0.7	0.341
5. People (professionals)	1	0.4	16	3.0	0.010
6. Desire / Interest (positive)	5	2.0	13	2.4	0.192
7. Desire / Interest (negative)	0	0.0	2	0.4	0.460
8. Nothing /no reason/no idea	10	4.0	67	12.5	<0.001
9. Advice	8	3.2	6	1.1	0.033
10. Undecided/not sure	0	0.0	4	0.7	0.211
Total	**253**	100.0	**534**	100.0	

From response rates in Table 4.26, the most popular response category was the Knowledge Based (positive) and Long Term (positive) for both DARA and Non-DARA students. There was no significant difference between the Non-DARA students and the DARA students for the Resources, Short Term, People (professional), Desire / Interest (positive), Desire / Interest (negative) and Undecided/not sure categories for what their teachers did to inform or inspire them about careers in Physics. Non-DARA students responded higher (59.3%) for the Knowledge Based (positive) category than the DARA students (54.3%). This shows that the Non-DARA students have more Knowledge Based (positive) goals for what their teachers did to inform or inspire them about careers in Physics than the DARA students. Non-DARA students responded higher (22.5%) for the Long Term (positive) category than the DARA students (15.5%). This shows that the Non-DARA students have more Long Term (positive) goals for what their teachers did to inform or inspire them about careers in Physics than the DARA students. DARA students responded higher (12.5%) for the Nothing /no reason/no idea/no category than the Non-DARA students (4.0%). This shows that DARA students have more Nothing /no reason/no idea/no for what their teachers did to inform or inspire them about careers in Physics than the Non-DARA students. Non-DARA students responded higher (3.2%)

for the Advice category than the DARA students (1.1%). This shows that the Non-DARA students had more Advice for what their teachers did to inform or inspire them about careers in Physics than the DARA students.

The Knowledge Based (positive), Long Term (positive), nothing /no reason/no idea/no and Advice categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA students in these categories in terms of what their teachers did to inform or inspire them about careers in Physics.

Table 4.27: Question 37 (What did your teacher do to inform or inspire you about careers in Physics?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
Non-DARA	43	**249**	292	**85.3**
DARA	211	**399**	610	**65.4**
Total	254	648	902	**150.7**

Table 4.27 shows that 249 (85.3%) Non-DARA students and 399 (65.4%) DARA students responded to the question above which gave a significance of <0.001 and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.28: Non-DARA/DARA students' response to open ended question 41 (What does GRAO stands for?)

Description	**Non-DARA Tally**	**Non-DARA %**	**DARA Tally**	**DARA %**	**Significance**
1. Correct/right	156	61.2	317	65.4	0.034
2. Incorrect/wrong	99	38.8	168	34.6	0.034
Total	**255**	100.0	**485**	100.0	

From response rates in Table 4.28, there was significant difference between the Non-DARA students and the DARA in terms of Correct/right and Incorrect/wrong categories for stating what GRAO stands for. DARA students responded higher (65.4%) for the Correct/right category than the Non-DARA students (61.2%). This shows that the DARA students were more able to state what GRAO stands for than the Non-DARA students. Non-DARA students responded higher (38.8%) for the Incorrect/wrong category than the DARA students (34.6%). This shows that the Non-DARA students were more unable to state what GRAO stands for than the DARA students. The DARA students answered these question more than the Non-DARA students; hence, the DARA students stated what GRAO stands for more than the Non-DARA students.

Table 4.29: Question 41 (What does GRAO stands for?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
Non-DARA	44	**248**	292	**84.9**
DARA	125	**485**	610	**79.5**
Total	169	733	902	**164.4**

Table 4.29 shows that 248 (84.9%) Non-DARA students and 485 (79.5%) DARA students responded to the question above, which gave a significance of 0.01, and this shows that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

Table 4.30: Non-DARA/DARA students response to open ended question 44 (In what ways have your knowledge/experience of the GRAO telescope affected your interest in Physics?)

Description	**Non-DARA Tally**	**Non-DARA %**	**DARA Tally**	**DARA %**	**Significance**
1. Knowledge Based (positive)	41	23.0	111	40.8	0.0343
2. Long Term (positive)	3	1.7	9	3.3	0.146
3. Short Term	0	0.0	18	6.6	<0.001
4. Desire / Interest (positive)	3	1.7	20	7.4	0.004
5. Desire / Interest (negative)	3	1.7	3	1.1	0.275
6. Nothing /no reason/no idea	128	71.9	95	34.9	<0.001
7. I have not been there	0	0.0	16	5.9	0.000
Total	**178**	100.0	**272**	100.0	

From response rates in Table 4.30, DARA students responded higher (40.8%) for the Knowledge Based (positive) category than the Non-DARA students (23.0%), this shows that the DARA students had more Knowledge Based (positive) ways in which their knowledge/experience of the GRAO telescope which has affected their interest in Physics than the Non-DARA students. DARA students responded higher (3.3%) for the

Short Term category than the Non-DARA students (1.7%). This shows that the DARA students had more Short Term ways in which their knowledge/experience of the GRAO telescope that has affected their interest in Physics than the Non-DARA students. DARA students responded higher (7.4%) for the Desire / Interest (positive) category than the Non-DARA students (1.7%). This shows that the DARA students had more Desire / Interest (positive) ways in which their knowledge/experience of the GRAO telescope that has affected their interest in Physics than the Non-DARA students. Non-DARA students responded higher (71.9%) for the Nothing /no reason/no idea/no category than the DARA students (34.9%). This shows that the Non-DARA students had more nothing/no reason/no idea/no ways in which their knowledge/experience of the GRAO telescope which has affected their interest in Physics than the DARA students. DARA students responded higher (5.9%) for the I have not been there category than the Non-DARA students (0.0%). This shows that the DARA students had more I have not been there ways in which their knowledge/experience of the GRAO telescope that has affected their interest in Physics than the Non-DARA students.

There was no significant difference between the Non-DARA students and the DARA students for the Long Term (positive) and Desire / Interest (negative) categories for ways in which their knowledge/experience of the GRAO telescope has affected their interest in Physics. The Knowledge Based (positive), Short Term, Desire / Interest (positive), Nothing /no reason/no idea/no and I have not been there categories were significant and the other categories were not. This shows that there was significant difference between DARA and Non-DARA students in these categories in terms of ways in which their knowledge/experience of the GRAO telescope has affected their interest in Physics.

Table 4.31: Question 44 (In what ways have your knowledge/experience of the GRAO telescope affected your interest in Physics?)

Schooltype	**0.00**	**1.00**	**Total**	**% Response**
Non-DARA	120	**172**	292	**58.9**
DARA	352	**258**	610	**42.3**
Total	472	430	902	**101.2**

Table 4.31 shows that 172 (58.9%) Non-DARA students and 258 (42.3%) DARA students responded to the question above which gave a significance of <0.001 and this shows

that there was a significant difference in the proportion of DARA and Non-DARA students that responded/answered the question.

4.7 Summary of Student's Questionnaire Analysis

This section gives the summary of the quantitative analysis of the students' questionnaires. Table 4.32 shows the summary of the analysis of the Kruskal Wallis H test. It indicates the questions, the school type (DARA and Non-DARA), the the highest and lowest mean ranks, the Kruskal Wallis value (H-value), the probability value (P-value), whether the questions were significant or not and the variation within the schools.

Table 4.32: Summary of Kruskal-Wallis H Test Analysis

Question	**School**	**Highest Mean Rank**	**Lowest Mean Rank**	**Kruskal-Wallis H-Value**	**P-Value**	**Highest**
1. Physics is useful in our daily lives.	Non-DARA	171.52	102.18	25.976	.001*	DARA
	DARA	396.97	169.00	49.941	.000*	
2. I like Physics better than any subject	Non-DARA	176.72	119.78	10.457	.164	DARA
	DARA	362.61	238.74	17.276	.139	
3. Physics should be made optional in our educational cur.	Non-DARA	173.51	115.42	12.915	.074	DARA
	DARA	416.62	261.06	24.902	.015*	
4. Physics increases my ability to think	Non-DARA	190.28	120.95	18.267	.011*	DARA
	DARA	394.45	243.30	41.743	.000*	
5. Physics runs through many subjects	Non-DARA	197.92	87.39	51.672	.000*	Non-DARA
	DARA	412.55	241.53	38.955	.000*	
6. Physics increases my ability to solve	Non-DARA	186.32	116.51	26.785	.000*	Non-DARA
	DARA	356.70	259.55	17.805	.122	
7. I enjoy Physics problems	Non-DARA	196.00	96.79	60.425	.000*	Non-DARA
	DARA	373.57	212.53	39.661	.000*	

8. Stop studying Physics if it's optional	Non-DARA	173.61	131.69	8.382	.300*	DARA
	DARA	351.58	227.84	23.941	.021*	
9. My teacher was my main influence in liking Physics	Non-DARA	170.48	104.78	17.106	.017*	DARA
	DARA	369.30	233.69	53.647	.000*	
12. Is it relevant to study Physics at SHS?	Non-DARA	188.25	115.58	33.318	.000*	Non-DARA
	DARA	359.02	224.25	30.677	.002*	
14. Is it relevant to study Physics at CoE?	Non-DARA	178.15	106.15	18.604	.010*	DARA
	DARA	380.48	220.96	57.675	.000*	
16. Is it relevant to study Physics at Universities?	Non-DARA	177.84	102.40	28.616	.000*	DARA
	DARA	366.84	238.39	44.633	.000*	
19. Physics is relevant to the kind of work you want to do	Non-DARA	201.90	117.23	37.867	.000*	DARA
	DARA	438.73	231.39	67.401	.000*	
20. Physics is important for the country's future wealth	Non-DARA	169.43	119.09	16.797	.019*	DARA
	DARA	367.70	245.69	19.436	.079	
21. Physics helps me to solve problems in life	Non-DARA	189.39	80.8	58.526	.000*	DARA
	DARA	374.92	217.58	55.037	.000*	
22. Study Physics because you had no choice	Non-DARA	167.83	112.75	13.782	.055	DARA
	DARA	380.53	207.76	32.012	.001*	

23. Study Physics because of range of jobs available	Non-DARA	165.93	81.2	41.274	.000*	Non-DARA
	DARA	349.03	248.89	21.452	.044*	
24. Study Physics because you are good at it	Non-DARA	203.98	106.79	48.099	.000*	DARA
	DARA	411.61	189.50	57.661	.000*	
25. Study Physics because you have interest in it	Non-DARA	183.13	114.13	26.181	.000*	DARA
	DARA	385.42	160.69	70.131	.000*	
26. Will you choose to study Physics at the SHS?	Non-DARA	203.32	108.95	37.937	.000*	DARA
	DARA	409.47	209.83	58.276	.000*	
27. Will you choose to study Physics at the CoE?	Non-DARA	194.58	112.21	31.432	.000*	DARA
	DARA	413.50	179.20	67.199	.000*	
28. Will you choose to study Physics at the Universities?	Non-DARA	190.99	114.02	31.423	.000*	DARA
	DARA	413.08	199.21	62.188	.000*	
33. I'm planning a career that uses Physics	Non-DARA	189.06	113.68	28.397	.000*	DARA
	DARA	417.92	176.68	78.359	.000*	
38. Job satisfaction is more important to me	Non-DARA	172.87	110.20	21.689	.003*	DARA
	DARA	410.03	224.31	41.388	.000*	
39.	Non-DARA	185.36	105.36	38.893	.000*	DARA

Have you been taught ''telescopes''?	DARA	385.07	196.50	70.904	.000*	
40. Are you aware of the DARA project in Ghana ?	Non-DARA	166.83	127.95	8.208	.315	DARA
	DARA	384.93	196.78	99.899	.000*	
42. Do you know where the GRAO is located?	Non-DARA	159.03	125.38	10.590	.158	DARA
	DARA	404.12	172.26	206.143	.000*	
43. Have you gone on an excursion to the GRAO telescope ?	Non-DARA	155.85	140.01	6.106	.527	DARA
	DARA	366.78	201.81	123.225	.000*	

Table 4.33 indicates the summary of the analysis of the Mann-Whitney U test. The table indicates all the questions, the schools that is DARA and Non-DARA, the mean rank, the Mann-Whitney value (U-value), the significance (whether the question is significant or not, the larger values (whether the questions had larger values) and the Pearson/Spearman direction for the questions that shown a significant difference of the Mann-Whitney U test.

Table 4.33: Summary of Mann-Whitney U Test Analysis

Question	School	Mean Rank	U-Value	P-Value	Larger Values	Pearson/Spearman Direction for only Significant Difference
1. Physics is useful in our daily lives.	Non-DARA	443.82	86816.500	.528	DARA	
	DARA	455.18				
2. I like Physics better than any subject	Non-DARA	455.13	87999.000	.765	Non-DARA	
	DARA	449.76				
3. Physics should be made optional in our educational cur.	Non-DARA	468.06	84224.500	.171	Non-DARA	
	DARA	443.57				
4. Physics increases my ability to think	Non-DARA	428.01	82065.500	.052*	DARA	Positive
	DARA	461.25				
5. Physics runs through many subjects	Non-DARA	472.24	83004.000	.083	Non-DARA	
	DARA	441.57				
6. Physics increases my ability to solve	Non-DARA	413.16	77622.500	.003*	DARA	Positive
	DARA	465.41				
7. I enjoy Physics problems	Non-DARA	439.00	85410.000	.306	DARA	
	DARA	457.48				
8.	Non-DARA	459.08		.535	Non-DARA	

Stop studying Physics if it's optional	DARA	447.87	86848.000			
9. My teacher was my main influence in liking Physics	Non-DARA	411.84	77479.000	.001*	DARA	Positive
	DARA	470.49				
12. Is it relevant to study Physics at SHS?	Non-DARA	444.61	87049.000	.540	DARA	
	DARA	454.80				
14. Is it relevant to study Physics at CoE?	Non-DARA	423.69	80938.500	.017*	DARA	Positive
	DARA	464.81				
16. Is it relevant to study Physics at Universities?	Non-DARA	401.89	73311.000	.002*	DARA	Positive
	DARA	455.08				
19. Physics is relevant to the kind of work you want to do	Non-DARA	431.66	77890.000	.002*	DARA	Positive
	DARA	466.68				
20. Physics is important for the country's future wealth	Non-DARA	426.44	81337.000	.086	DARA	
	DARA	455.39				
21. Physics helps me to solve problems in life	Non-DARA	394.47	71778.000	.000*	DARA	Positive
	DARA	465.47				
22. Study Physics because you had no choice	Non-DARA	481.61	76867.000	.004*	Non-DARA	Negative
	DARA	429.76				

23. Study Physics because of range of jobs available	Non-DARA	388.16	69768.500	.000*	DARA	Positive
	DARA	459.85				
24. Study Physics because you are good at it	Non-DARA	361.19	62479.500	.000*	DARA	Positive
	DARA	490.07				
25. Study Physics because you have interest in it	Non-DARA	389.05	70429.000	.000*	DARA	Positive
	DARA	473.90				
26. Will you choose to study Physics at the SHS?	Non-DARA	422.36	80552.500	.016*	DARA	Positive
	DARA	465.45				
27. Will you choose to study Physics at the CoE?	Non-DARA	395.76	72470.000	.000*	DARA	Positive
	DARA	474.31				
28. Will you choose to study Physics at the Universities?	Non-DARA	396.93	72480.500	.000*	DARA	Positive
	DARA	471.98				
33. I'm planning a career that uses Physics	Non-DARA	393.82	71697.500	.000*	DARA	Positive
	DARA	463.80				
38. Job satisfaction is more important to me	Non-DARA	384.16	68926.000	.000*	DARA	Positive
	DARA	461.48				
39. Have you been taught ''telescopes''?	Non-DARA	436.86	84786.000	.198	DARA	
	DARA	458.51				

40. Are you aware of the DARA project in Ghana ?	Non-DARA	498.00	75481.500	.000*	Non-DARA	Negative
	DARA	429.24				
42. Do you know where the GRAO is located?	Non-DARA	539.92	63242.000	.000*	Non-DARA	Negative
	DARA	409.18				
43. Have you gone on an excursion to the GRAO telescope ?	Non-DARA	493.55	76781.000	.000*	Non-DARA	Negative
	DARA	431.37				

Table 4.34 indicates the summary of the analysis of the Pearson and Spearman correlations on the Mann-Whitney U test. The table indicates all the questions that had a significant difference in the Mann-Whitney U test, the type of correlations used (Pearson/Spearman), the Pearson and Spearman value (R-value), the probability value (P-value), the direction, and the strength.

Table 4.34: Summary of Pearson & Spearman Correlations on Mann Whitney U Test of Questions that Had Significant Differences

Question	Correlation	R-value	P-Value	Direction	Strength
4. Physics increases my ability to think	Pearson	.045	.176	Positive	Weak
	Spearman	.065	.052*		
6. Physics increases my ability to solve	Pearson	.090	.007*	Positive	Strong
	Spearman	.099	.003*		
9. My teacher was my main influence in liking Physics	Pearson	.081	.015*	Positive	Strong
	Spearman	.109	.001*		
14. Is it relevant to study Physics at CoE?	Pearson	.042	.212	Positive	Weak
	Spearman	.080	.017*		Strong
16. Is it relevant to study Physics at Universities?	Pearson	.095	.005*	Positive	Strong
	Spearman	.105	.002*		
19. Physics is relevant to the kind of work you want to do	Pearson	.0119	.000*	Positive	Strong
	Spearman	.101	.002*		
21. Physics helps me to solve problems in life	Pearson	.133	.000*	Positive	Strong
	Spearman	.138	.000*		
22.	Pearson	-.101	.002*		

Study Physics because you had no choice	Spearman	-.096	.004*	Negative	Strong
23. Study Physics because of range of jobs available	Pearson	.133	.000*	Positive	Strong
	Spearman	.137	.000*		
24. Study Physics because you are good at it	Pearson	.235	.000*	Positive	Strong
	Spearman	.239	.000*		
25. Study Physics because you have interest in it	Pearson	.155	.000*	Positive	Strong
	Spearman	.162	.000*		
26. Will you choose to study Physics at the SHS?	Pearson	.74	.027*	Positive	Strong
	Spearman	.080	.016*		
27. Will you choose to study Physics at the CoE?	Pearson	.148	.000*	Positive	Strong
	Spearman	.146	.000*		
28. Will you choose to study Physics at the Universities?	Pearson	.138	.000*	Positive	Strong
	Spearman	.140	.000*		
33. I'm planning a career that uses Physics	Pearson	.128	.000*	Positive	Strong
	Spearman	.134	.000*		
38. Job satisfaction is more important to me	Pearson	.154	.000*	Positive	Strong
	Spearman	.150	.000*		
40.	Pearson	-.043	.195		Weak

Are you aware of the DARA project in Ghana ?	Spearman	-.140	.000*	Negative	Strong
42. Do you know where the GRAO is located?	Pearson	-.114	.001*	Negative	Strong
	Spearman	-.281	.000*		
43. Have you gone on an excursion to the GRAO telescope ?	Pearson	-.038	.252	Negative	Weak
	Spearman	-.164	.000*		Strong

4.8 Major Findings from the Students Questionnaire

- Non-DARA students had positive attitudes towards the learning of Physics more than the DARA students.
- Non-DARA students gave more major reasons why they would choose to study Physics at the SHS, CoE and Universities more than the Non-DARA students.
- Non-DARA students had better perceptions on the relevance of studying Physics more than the Non-DARA students.
- Non-DARA students had better career aspirations and awareness in careers related to Physics more than DARA students.
- Majority of DARA students were more aware of radio astronomy than the Non-DARA students. Hence, there was significant difference between DARA and Non-DARA students on the awareness of radio astronomy.
- The Non-DARA students support the idea that the subject Physics has some, if not a lot usefulness.
- Some DARA students pointed out that, their teachers did nothing to inspire them to study Physics and also there was nothing to motivate or to serve as a driving force for them to pursue the subject at higher educational levels.
- DARA students knew of more Physics careers (career aspirations in Physics) than Non-DARA students and also they were more aware of the GRAO telescope/DARA project in Ghana than Non-DARA students.

Chapter 5 : Results and Findings on Teachers' Interview

5.1 Overview

This study was to specifically understand the impact of large-scale radio astronomy projects on student engagement with Physics in Ghana. This chapter presents the data analysis and interpretation of the findings of the teacher's interview. The chapter presents the information of the teachers and the analysis of the teachers' interview according to the research objectives of the teachers. This chapter also presents the findings of the teachers' interview from the study. The results are presented in section 5.2 and 5.21. For each interview question the teachers' responses were compared with their students' responses from the survey questions (section 4.4). These indicated areas of agreement or shared perspectives between the two groups compared with the RQ. Comparison of the responses of teachers and students was done to identify any differences or discrepancies in their views. This comparison was done likewise for all teachers who took part in the interview.

5.2 Extracts of DARA Teachers

Thirteen DARA teachers were interviewed which consist of 10 men and three women. Eight questions were asked on RQ6, one question was asked on both RQ7 and RQ8 for each teacher. All the interview questions (Table 3.7) asked were based on the RQs (section 1.15). These are seen in the extracts below:

1. **Researcher: Why did you choose to get involved with the DARA training?**

Teacher 1 (Gab): *''I considered it has an opportunity that I have to take so that it can really propel me to the next level in life.''*

Teacher 2 (Mirek): *''I chose to involve in the DARA training basically to give me the opportunity to further studies and also to broaden my knowledge about the whole concept of radio astronomy basically.''*

Teacher 3 (Geo): *''I'm in the Physics fraternity as a teacher or Physics teacher in my school I wanted to enhance knowledge in the Physics in general. I had interest also in furthering my education in astronomy and Physics as a whole.''*

Teacher 4 (Nesto): *''I have been a science student and therefore I am more conversant with Physics as far as I know and therefore I wanted to get broader knowledge with things that involves Physics.''*

Teacher 5 (King): *''During my undergraduate degree I was involved in the astronomy workshop at the planetarium and that was what rekindled my* *interest in astronomy and as a Physics student I was willing to study and see what the planets is all about . After university I was interested in pursuing such goals and thankfully DARA came in to train some students in this field and I applied immediately and I was lucky to be selected to be part of the training.''*

Teacher 6 (Zeb): *''To be able to teach my students on science and Physics topics related to astronomy and also for me to know the importance of astronomy in Ghana and why astronomy should be introduced in schools across Ghana.''*

Teacher 7 (Kat): *''As a teacher I have to be abreast with a lot of issues, to be able to train myself to a certain level to help my children and my teaching work. So when the opportunity for DARA came I was glad to join so that I can improve on my teaching skills and the knowledge about science particularly Physics.''*

Teacher 8 (Ceph): *''I'm a science person, I have been teaching science for over ten years now so when the idea was sold to me, I deem it a great privilege to have join the DARA programme . Besides that, most of the topics that they taught challenging topics that I find to teach my students to understand very well.''*

Teacher 9 (Bunya): *''To improve my professional development in Physics. I'm a science coordinator, that opportunity will help me train my colleagues to teach science /Physics very well in the schools. To engage students in the DARA activities so that they will become very much interested in Physics.''*

Teacher 10 (Saddi): *''I happen to be a social studies teacher and for that matter I have love for science because when I was in SHS I read Physics and more or less I read Agricultural science and I was so much interested in science. So, when the opportunity came I took advantage of it.''*

Teacher 11 (Debbie): *''I didn't choose it but when they came they said they wanted someone who was a science teacher to be part of the programme . I was the science teacher, so I was selected to be part. There was no specific reason because the kids will be doing a lot of activities, they needed a teacher to be with them.''*

Teacher 12 (Patty): *''I realise that the training will give me more insight into a lot of things in astronomy to be able to impact it on my students and it will enhance their interest in pursuing that aspect of science.''*

Teacher 13 (Wise): *''It all started when I was doing my national service at the University of Cape Coast (UCC) where there was an astronomy programme that was held by the European Southern Observatory (ESO) and the Physics department of the UCC. I happened to have joined that programme that motivated me to go into the field of astrophysics and take any opportunity that comes my way and that seeks to train people in the area of astrophysics.''*

2. *Researcher:* **How has DARA changed the way you teach?**

Teacher 1 (Gab): *''A lot, through some of the activities from the hands on activities that we were engaged in during the DARA programme , it has broaden my teaching methods that I used in teaching my students. Now students are can get a quicker understanding to some areas in Physics or in science. So, in all I can say that it has really promoted the interest of science.''*

Teacher 2 (Mirek): *''In relation to how I teach I can say that it has enriched my knowledge especially if it comes to things that are related to space or astronomy in general because of this at least am able to give very practical examples whenever am teaching concepts that are related to astronomy specifically and the Physics that deals with some these astronomical bodies. So, it has enriched the content that I used to teach.''*

Teacher 3 (Geo): *''I'm able to confidently communicate my content with facts and evidence.''*

Teacher 4 (Nesto): *''It has helped me to be able to see the world in the scientific view. It has changed my perception about religion and other beliefs about the earth. First, I use to teach in abstract terms but now I use concrete materials like projectors to show the kids some of the scientific findings that can really help them to understand science.''*

Teacher 5 (King): *'It has introduced me to enquiry-based learning and how to also use different methods in teaching Physics and maths especially with images and questions and these has really transformed the way the students understand Physics.''*

Teacher 6 (Zeb): *''DARA has taught me a lot of things about the solar system and the effect on the lives of every individual in the world. It has shaped me to be more practical ways to teach using teaching aids, satellites and the structure of the moon now my students are able to know the distance between the various planets because of DARA.''*

Teacher 7 (Kat): *''It has given me confidence as to the knowledge of astronomy, the observatory visitation has also helped me to know much about how information are accessed. It has motivated me, boosted my confidence and also it has helped me to incite my students in the teaching of science making them to be very active in class, when I teach they are able to participate very well. It has really helped me to improve my skills, the resources obtained from DARA has really helped me to be able to teach using Teaching Learning Materials (TLMs) to aid my teaching in the classroom.''*

Teacher 8 (Ceph): *''I think hitherto everything has been on the grounds of abstract, children have to imagine most of the concepts taught in class, but by joining this programme I have been able to learn new skills so I have been able to create miniature TLMs and this has boost the interest of the students in Physics.''*

Teacher 9 (Bunya): *''Most of the DARA activities were hands-on. So when I came back, I did the same thing by using a lot of the hands-on activities and that has improve the way our teachers teach in the classroom''.*

Teacher 10 (Saddi): *''As a result of what I learnt, I embark on some projects with my students, we visited the GRAO. We visited the place and when we came back we decided to construct a prototype of the GRAO telescope using some already available locally made materials in our environment and we all participated in it.*

Teacher 11 (Debbie): *''When you look at the syllabus, we have a topic on the solar system but it doesn't cover a lot. I have gained enough knowledge to be able to teach and explain it very well to my students.''*

Teacher 12 (Patty): *''The training gave me the opportunity to use a lot of activities in my teaching. Initially, I was teaching some of the topics in abstract terms but now am able to use a lot of activities and this has boost the students interest.''*

Teacher 13 (Wise): *''It has immensely helped me in the way I teach certain topics in class, given me a better opportunity to explain the technicalities and it helped me to give my students a better understanding on topics that are related to astronomy and other areas related to Physics.''*

3. **Researcher: How has DARA impacted on your students towards Physics?**

   Teacher 1 (Gab): *''On my students, they have really gotten a broader scope and understanding on the topics in Physics. Since the inception of the astronomy club in my school talking about students' interest in terms of attendance has increased. It has boosted their interest in studying science/ Physics in the school and assessment in terms of their mock, class tests and exams have gone a little bit higher than it used to be ''*

For questions like this the teacher response was compared to that of their students. By way of example teachers interview question three was compared to the students questionnaire question 39, 40 and 42. For students question 39 ''Have you been taught the topic ''telescopes'' in class?'' see figure 4.72. For students question 40 ''Are you aware of the DARA project in Ghana?'' see figure 4.74. For students question seven 42 ''Do you know where the GRAO telescope is located?'' see figure 4.76.

Comparing Gab's response to that of his students' response at Kwabenya Community SHS and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Gab said the programme has really promoted the interest of science which was in agreement with what his students at Kwabenya Community SHS responded to on question 9 and 25 on the student's questionnaire but his students at GAEC Basic School were only in agreement with question 9.

> ***Teacher 2 (Mirek):*** *''I'm able to help my students to appreciate the concepts in Physics more. So, it has helped them to also get more appreciation of concepts that are related to astronomy. It has impacted on the students' performance because once it helps improve their appreciation of the concepts it also leads to improving their understanding which impacts their performance directly. It improves and deepens their understanding which in effect affects and enhances their performance because once students understand the concepts you are teaching very well, it is easy for them to also apply them in exams and other stuffs given to them.''*

Comparing Mirek's response to that of his students' response and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers.

> ***Teacher 3 (Geo):*** *''I have insight of what I teach my students, I love my teaching and they are always happy to see me because I give very practical and insightful content and examples for them to understand, so they appreciate the Physics. With their performance, I don't have the figures because before the DARA training I taught a different class and after it I am teaching a different class so I will not be able to assess the difference or the impact but looking at the feedback I get from the students as to their love for Physics and how they appreciate it I can see that now my teaching is much enhanced than before.''*

Comparing Geo's response to that of his students' response and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Geo said that looking at the feedback he got from his students, their love for Physics has increased which was in agreement with question 25 but in disagreement with question 9 on the student's questionnaire.

> ***Teacher 4 (Nesto):*** *''They have really embraced Physics very well. They now see that Physics can have a lot of impact in their lives and a lot of contributions. For instance, there are a lot of people who want to undertake Physics at the next level some of them want to go into astronomy and different areas. In our classrooms sometimes if you introduce Physics the children were not interested, they don't like it because they see it as challenging; but now, they have really embraced it because it explains everything around them; hence, they are really interested.''*

Comparing Nesto's response to that of his students' response and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Nesto said that the programme has impacted a lot on the lives and brought a lot of contributions to his students, they have embraced and are really interested in Physics which was in agreement with questions 9, 14, 16, 18, 19, 20, 25, 29 and 31 on the student's questionnaire.

> ***Teacher 5 (King):*** *''It has made them now to love Physics. They are able to understand the concepts in Physics and how it affects their daily lives. They can now build certain things by themselves. Before the DARA training the knowledge about Physics on the solar system was not there but after it has helped them to be able to answer questions more practical. Their performance before was not all that good but now I can say that their performance is excellent.''*

Comparing Kings's response to that of his students' response and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. King said that the programme has made his students to love Physics, they were able to understand the concepts in Physics, how it affects their daily lives and their performance had been excellent which was in agreement with questions 1, 9, 24, 25, and 44 on the student's questionnaire.

> ***Teacher 6 (Zeb):*** *''They are all interested to know more about Physics. I had some nice exposure to the universe, to space, even questions that were formerly unknown to me and this really increased my curiosity and during teaching I usually give them such statements on something that will interest them, that will make them curious about the world and I can see that most of students are having a change in attitudes towards science and how they all want to understand how things go around the world, how is mars been developed at the moment, what is happening to Pluto. They are really interested in science have been really glued to their shoes and they have confidence in learning Physics at higher levels.''*

Comparing Zeb's response to that of his students' response and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Zeb said that the programme has made his students to be interested in Physics, a change in attitudes towards science, they were able to understand the concepts in Physics, how it affects their daily lives, had more knowledge in Physics, had glued their shoes and they were confidence in learning Physics at higher levels which was in agreement with questions 9, 10, 12, 14, 16, 25, and 44 on the student's questionnaire. His response also indicates that he had made them to like Physics which relates to question 11 on the student's questionnaire.

> ***Teacher 7 (Kat):*** *''The children have been blessed, they are happy and enthusiastic to participate in DARA because the whole programme comes with real life situations. They are made part of it to know what goes into it. For example, the visiting of the observatory made the students very happy to know how things work because as children of this community they have seen the dish and they did not know much about it. All these involvements have helped them to enjoy and have interest in science. My interaction with them shows that they are enthusiastic and involved themselves in the teaching and learning process. The performance of the students is very good after the DARA as compared to before DARA. Most of them are prospecting to offer science at the SHS.''*

Comparing Kat's response to that of her students' response and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Kat said that the programme has made her students to understand real life situations, visted the GRAO, enjoy and have interest in science, had more knowledge in Physics, performance of the students were very good and Most of them were prospecting to offer science at the SHS which was in agreement with questions 9, 12, 18, 25, 27, 42, and 44 but was in disagreement with questions 1 and 24 on the student's questionnaire.

> ***Teacher 8 (Ceph):*** *''After the training, I and my students were designing and constructing a prototype of GRAO telescope, I have some students who ask me whether the DARA people are not coming. They use to pressure me a lot and at the time we were constructing the telescope they use to ask me that when we are going finish with the construction of the telescope. This really shows that they have fallen in love with Physics. The students were very active in it, I have the videos/shots there as evidence. Some told me they would like to offer science/Physics at the SHS. Those that graduated last year one of them is offering science at the SHS and reading Physics. Initially girls were not interested in science before attending the DARA programme but after they have all shown much interest in science/Physics. In terms of performance before DARA the students were not doing well but after their performance has improved tremendously.''*

Comparing Ceph's response to that of his students' response also with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Ceph said that the programme has made his students to have more knowledge in Physics, enjoy and have interest in science/Physics, they would like to offer science/Physics at the SHS and their performance had improved tremendously which was in agreement with questions 9, 12, 24, 25, 27 and 44 on the student's questionnaire.

> ***Teacher 9 (Bunya):*** *''By joining this programme in fact I have come to realised that it is actually based on the pedagogy or methodology that we employ that as actually brings about phobia in Physics. It has actually helped me so students as I speak to you now are interested in Physics. I participated in DARA last year and by that time the final year students have about four or five months to write their exams, at that same time they were supposed to choose programmes of study at the SHS, and science was something most of them will not like to offer. Most students prefer the arts, business courses to science, but because the DARA activities are activity based, in fact students regretted that they have to leave school before the DARA came in because they really enjoy the club activities. It will amaze you that anytime it is due for club meetings they even keep reminding me about the time for club meetings, the interest level was so high. A handful of them are in the SHS pursuing science.''*

Comparing Bunya's response to that of his students' response and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Bunya said that the programme has made his students to enjoy and have high interest in Physics and offer science at the SHS which was in agreement with questions 9, 12, 25 and 27 on the student's questionnaire.

> ***Teacher 10 (Saddi):*** *''The students get involved with the hands-on activities and get interested. Some of them anytime you want to talk about Physics concepts, they are interested because whatever you are teaching is not in abstract, all concepts is based on hands-on activities and this has really helped our students. There has been a change before the DARA and after because we didn't know we can teach using hands-on activities we are teaching in abstract so after the training we started using the hands-on activities to teach basic Physics concepts and the students have interest and enjoy. This has really change students' attitudes and other activities. The students are doing very well sometimes when they write exams, we look at the Physics part of their questions and we see that majority of them do well in answering them which at first wasn't the case, they perform well based on the hands-on activities and they really understood the concepts very well. The hands on activities are very important for them to understand basic concepts and principles in Physics.''*

Comparing Saddi's response to that of his students' response and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Saddi said that the programme has made his students to enjoy and have interest in Physics, had really change students attitudes, majority of his students were doing very well in the Physics part of science, had more knowledge and the hands-on activities wre very important for them to understand basic concepts and principles in Physics which was in agreement with questions 9, 10, 18, 24, 25 and 44 on the student's questionnaire.

> ***Teacher 11 (Debbie):*** *''Some of the students were not having interest in Physics, they were thinking it is difficult but when they join the club meetings they have been able to gain interest in Physics. When I compare the performance of the students before the DARA and after the DARA, I can say that their performance before was not good but after the introduction of the DARA their performance has improved, it is better now and they are doing well.''*

Comparing Debbie's response to that of her students' response also with research question seven indicates that she was in agreement but the students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Debbie said that the programme has made her students to gain interest in Physics which was in agreement with question 25 but was in disagreement with question 9 on the student's questionnaire. Her response also indicated that the performance of her students has improved which was in agreement with question 24 but was in disagreement on the student's questionnaire.

> ***Teacher 12 (Patty):*** *''Now the students like and enjoy studying Physics after the DARA. The performance has improved. They were learning in abstract, so the learning was very difficult for them but now because of the activities, simple experiments etc. When a question is asked because of the hands-on activities, they are able to remember what they did and answer the questions well. In 2018, I had about four students pursuing science at the SHS but in 2019 the number increased to twelve. Majority of the students now want to offer science and for that matter study Physics as a subject.''*

Comparing Patty's response to that of her students' response and with research question seven indicates that they were both in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Patty said that the programme has made her students to like and enjoy studying Physics, their performance had improved, able to remember what they did and answer questions well and majority of the students would want to offer science and for that matter study Physics as a subject which was in agreement with questions 12, 14, 16, 24, 25, 27, 29, 31 and 44 on the student's questionnaire. Her response also indicated that her students like and enjoy studying Physics which was in disagreement with question 9 on the student's questionnaire.

Teacher 13 (Wise): *''It gives me the opportunities that are outside there in Physics so I always tell my students what they can do with the learning of Physics and how they can apply it and the various aspects or careers they can find in future. The students usually shy away from Physics but based on my engagement with DARA and kind of exposures and experiences I discuss with them, a good number of them have shown passion and reading further in the areas of Physics. Going forward after SHS, some have plans to go into the field of applying Physics in the kind of career. Some have even decided to find more about the area of astrophysics even though they are doing technical programme . Their performance has been improved a little bit; we expect to see higher improvements as the years go by because I only completed the DARA programme just last year. Going forward I will like to engage more students that will be enrolled so the expectation will be to get better improvements than just what we have now after the DARA.''*

Comparing Wise's response to that of his students' response and with research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for DARA teachers. Wise said that the programme has made his students understand the relevance of studying Physics, had discuss experiences and knowledge in Physics with them, had shown passion in Physics and had plans in studying Physics which was in agreement with questions 9, 12, 14, 16, 18, 25, 26, 27, 28, 29, 31 and 44 on the student's questionnaire. Her response also indicated that his students' performance had improved a little bit and had plan to go into the field of applying Physics in the kind of career which was in disagreement with question 24 and 37 on the student's questionnaire.

4. **Researcher: Has there been a change in the attitudes of the students you teach towards Physics? If ''Yes'' why and if ''No'' why?**

   Teacher 1 (Gab): *''Yes, firstly they have a higher interest. Secondly, their attitude towards Physics or learning Physics is also on the rise and then in all it has also contributed to the general performance in the students' academic works in terms of Physics exams and other assessments. We can get their scripts as evidence*.''

Comparing Gab's response to that of his students' response and with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Gab said that the programme had contributed to the general performance in this students' academic works in Physics exams and other assessments in which was in disagreement with what the students responded to on question 24 on the student's questionnaire. With regards to GAEC Basic School, Gab's response that the students had a higher interest was in disagreement with what the students responded on question 25 on the student's questionnaire.

Teacher 2 (Mirek): *''Yes, because am now able to give more practical examples to some of the things. They appreciate it more so they get more excitement. They appreciate it more and once they appreciate it more their attitudes towards Physics are more receptive of Physics, it is no more too abstract for them. So now they enjoy the Physics more and it has really helped in the appreciation of the Physics concepts.''*

Comparing Mirek's response to that of his students' response and also with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Mirek said that the programme had really helped his students in the appreciation of Physics concepts which was in agreement with what the students responded to on question 25 but was in disagreement on question 9 on the student's questionnaire.

Teacher 3 (Geo): *''Mostly, there has been a slight change because of the DARA training I have been able to whet some student's appetite for astronomical research and things about Physics so most of my students have their interest of Physics increased because they've seen that when they study Physics, they will have job opportunities and there are prospects.''*

Comparing Geo's response to that of his students' response and with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Geo said that most of his student's interest in Physics had increased and they would study Physics because they would have job opportunities and the prospects in it which was in agreement with what the students' responded to on question 25 and 23 on the student's questionnaire.

Teacher 4 (Nesto): *''Yes, as I said earlier they have really showed much interest in the subject and most of them are aspiring to be physicist in future.''*

Comparing Nesto's response to that of his students' response and with research question six indicates that both were in agreement on the attitudes towards teaching

Physics with regards to the interview question four for DARA teachers. Nesto said that most of his students had really showed much interest in the Physics and most of them are aspiring to be physicist in future which was in agreement with what the students' responded to on question 25 and 33 on the student's questionnaire.

Teacher 5 (King): *''Yes, now they love Physics they don't even wait for me to enter the class any time they have science or Physics. They normally come and search for me to come to the class to teach them, so the interest level is very high.''*

Comparing Kings's response to that of his students' response and with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Nesto said that his students had very high interest level in Physics which was in agreement with what the students' responded to on question 25 on the student's questionnaire.

Teacher 6 (Zeb): *''Quite recently after teaching them upthrust and buoyancy, law of floatation we research online or one of the news online was about a village that uses the principle of Physics to rescue a young elephant that fell into a pit using the principle of buoyancy and I came to put this on their notice board and also show it to them on their smartboards and they were really happy to see that just that small principle they learnt of floatation could save an animal from dying. I also showed them the documentary on the pi island how they really were able to build houses on the sea first of all using the principles of Physics. All these have motivated and inspired them that whatever they are learning can be useful in life and I think that is a good step.''*

Comparing Zeb's response to that of his students' response and with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Zeb said that his students had knowledge in Physics, were motivated and inspired to learn Physics, and learned the usefulness of Physics which was in agreement with what the students' responded to on questions 9, 10, 18 and 44 on the student's questionnaire.

Teacher 7 (Kat): *''Yes, because certain misconceptions and things they didn't know about have now been cleared. This has made them to be confident and has brought a change in them. Also knowing the sun to be a star but not a different thing, they now know the distances of objects in space and this gives them more urge to find out different things for themselves. There is a boy in my class who knows even more of the things I myself I don't know. He research, study a lot of things about space and goes the extra mile and all this is because of what DARA has inculcated into him.''*

Comparing Kat's response to that of her students' response and with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Kat said that his students had knowledge in Physics which was in agreement with what the students' responded to on question 44 on the student's questionnaire.

> ***Teacher 8 (Ceph):*** *''Yes, their attitudes have changed positively and always want to study science/Physics. They apply whatever they learn in Physics to social studies where we have same topics. In social studies we have some Physics dimension in it. They are so much interested when it comes to astronomy and astronomy club meetings.''*

Comparing Ceph's response to that of his students' response and with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Ceph said that his students had interest in Physics and applied whatever they learned in Physics to social studies which was in agreement with what the students' responded to on questions 5, 25 and 44 on the student's questionnaire.

> ***Teacher 9 (Bunya):*** *''Yes, very tremendous change. The change is as a result of the various activities that were carried out during the teaching of Physics and club meetings. Sometimes send them to the field and design a programme to arouse their interest in Physics. Measuring of distances between planets, playing of football etc. through the act of games the children were learning new things and it became so interesting that other teachers even join with the activities.''*

Comparing Bunya's response to that of his students' response and also with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Bunya said that he designed a programme to arouse his students' interest in Physics and the students learned new things which was in agreement with what the students' responded to on questions 25 and 44 on the student's questionnaire.

> ***Teacher 10 (Saddi):*** *''Yes, based on the hands-on activities and active participation in it. This has really changed their attitudes towards the study of Physics even though it is not 100% change. We will need to do more.''*

Comparing Saddi's response to that of his students' response and with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Saddi said that his students actively participated in Physics which was in agreement with what the students' responded to on question 25 on the student's questionnaire.

> ***Teacher 11 (Debbie):*** *''There has been somehow a change in the attitudes of the students towards Physics. Somehow, because we don't have enough materials, TLMs, we have some but they are few. This is a problem to us. When we use the TLMs they become very much interested because of the various activities involved. If we don't get the materials, they feel reluctant.''*

Comparing Debbie's response to that of her students' response and with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Debbie said that her students became very much interested because of the various activities involved which was in agreement with what the students responded to on question 25 on the student's questionnaire but was in disagreement with what her students responded to on question 9 on the student's questionnaire. Her response that student's felt reluctant if they don't get the materials for the various activities was in disagreement with what the students' responded to on question 8 on the student's questionnaire.

> ***Teacher 12 (Patty):*** *''Now if you go to class and you want to teach Physics they are very happy to learn because of the various activities involved. They are eager to learn Physics and take part in the activities. They enjoy studying Physics than they use to do formerly. This is because I now have in-depth knowledge about Physics and I am more confident in delivery it to my students because of this the students are also much interested in the subject.''*

Comparing Patty's response to that of her students' response and with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Patty said that her students were eager to learn Physics and take part in the activities, enjoyed and were much interested in studying Physics and had in-depth knowledge about Physics which was in agreement with what the students responded to on question 25 and 44 on the student's questionnaire but was in disagreement with what her students' responded to on question 9 on the student's questionnaire.

> ***Teacher 13 (Wise):*** *''Student's passion towards Physics is quite limited. There has been a change in their attitude in a quite number of students because now most of them want to have books that are Physics related unlike before when they were not interested in Physics because they saw Physics to be a very difficult subject. Now they've realised that Physics is fun, all around them they*

see things that are related to Physics and going forward they realise that pursuing Physics can enhance their career opportunities as well.''

Comparing Wise's response to that of his students' response and also with research question six indicates that both were in agreement on the attitudes towards teaching Physics with regards to the interview question four for DARA teachers. Wise said that his students had knowledge in Physics, were interested in Physics and had realised that pursuing Physics can enhance their career opportunities as well which was in agreement with what the students responded to on questions 12, 14, 16, 18, 19, 23, 25, 27, 29 31, 33 and 44 on the student's questionnaire but was in disagreement with what her students' responded to on question 35 on the student's questionnaire.

5. **Researcher: How do you inspire your students to engage with Physics learning and to further study Physics in the Senior High Schools / Universities / Colleges of Education / Polytechnics etc?**

Teacher 1 (Gab): *''I inspire them to know that Physics can help them explain certain phenomena at times it keeps them in the scope of their interest, and they always want to know and learn more about Physics. There are a number of careers that are having Physics as their background for example civil, aerospace, geomatics, electrical engineering, in fact anything engineering, medical Physics, research scientists and all these institutions and they realise that by studying Physics you yourself you just broaden your scope of opportunities in life. There are more job prospects in Physics, so I inspire them to study Physics. I advise them to be good citizens thereby trying to learn harder, be creative and innovative and applying some of this knowledge to be able to solve some petty problems/issues that is troubling our economy at times the good ones.''*

Comparing Gab's response to that of his students' response at Kwabenya Community SHS and GAEC Basic School with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Gab said that he explains certain phenomena to his students to keep them in the scope of their interest and always want to know and learn more about Physics, informed them about the job prospects and careers in Physics and also solve some petty problems/issues which was in agreement with his students at Kwabenya Community SHS with what they responded to on questions 6, 9, 21, 25 and 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire. Also, this was in agreement with what his students at GAEC Basic School responded to on questions 6, 9 and 21 but was in disagreement with questions 25, 33, 35, 36 and 37 on the student's questionnaire.

> ***Teacher 2 (Mirek):*** *''I do that by making the Physics practical to them that is one so that they get to know that Physics isn't abstract. Some of the concepts I introduce and teach them are things they can actually experience so I make the Physics practical to them. I also expose them to some of the opportunities the Physics world creates in terms of careers and other stuffs. So, by that it inspires them to study Physics knowing that at least it has a better and brighter future. It also creates a career part that they can ascribe to and become more responsible citizens in their future endeavours. They are willing to further to study Physics at the tertiary levels and their willing to do engineering. They come to ask which of the universities they should attend, which of the engineering courses they should pursue, which universities are appropriate for studying Physics.''*

Comparing Mirek's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Mirek said that he has exposed his students to some of the opportunities the Physics world creates in terms of careers and other stuffs and willing to further to study Physics at the tertiary levels which was in agreement with what his students responded to on questions 14, 16, 27, 28 and 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire.

> ***Teacher 3 (Geo):*** *''I always tell my students that Physics is lovely, it is about everything. So, I always tell them to be a critical thinker a scientist and a physicist is someone who is a critical thinker and can analyse things very well. With these sayings and encouragement most of my students love calculations and analytical concepts and those who don't even have interest are getting interest and some want to do Physics and other Physics related courses.''*

Comparing Geo's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Geo told his students that Physics is lovely, it is about everything, makes one to be a critical thinker, analytical and also his students are getting more interested in Physics and wants to learn Physics and other related courses which was in agreement with what his students responded to on questions 4, 14, 16, 25, 27, and 28 but was in disagreement with questions 1 and 9 on the student's questionnaire.

Teacher 4 (Nesto): *''Sometimes I try to use models to explain some of the things in Physics for instance I created how the solar system looks like using materials and I always use some of the materials available to explain certain concepts. Once in a while, I give them lectures on a lot of areas in Physics, some of the courses they can undertake and some of the job opportunities available after studying Physics etc. This inspires the students to undertake Physics because if they know that in future, they have the opportunity to go to space to learn things in space and wants to learn more because they want to see what is in space, how the world looks like and the whole earth and how it appears. They are willing to study Physics at the SHS and at the tertiary levels of education. Most of them I have engaged with are ready to study Physics at the SHS. Despite the fact that they know they have to learn very well and study a lot because it involves a lot of calculations etc they are still interested.''*

Comparing Nesto's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Nesto told his students about job opportunities available after studying Physics, to undertake Physics, to study Physics at the SHS and at the tertiary levels of education and are interested in Physics which was in agreement with what his students responded to on questions 9, 12, 14, 16, 18, 19, 23, 25, 26, 27, 28, 29, 30, 31, 32 and 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire.

Teacher 5 (King): *''The inspiration comes from what I have learned and what I have taught them now things are done in the practical way. Physics is practical, so now I do things more practical. There are a lot of opportunities there in Physics, Physics is not only reading when you read Physics a lot of doors will open for you. About five of them are studying science and they are doing elective Physics.''*

Comparing King's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. King told his students about a lot of opportunities there in Physics and willing to study Physics which was in agreement with what his students responded to on questions 12, 14, 16, 18, 19, 26, 27, 28, 29, 30, 31, 32 and 33 but was in disagreement with questions 35, 35 and 37 on the student's questionnaire.

Teacher 6 (Zeb): *''Currently, most of them have in mind to become doctors and engineers mainly, but when I started teaching them I now have a lot who wants to be scientists, astronomers, astrophysicists , data scientists because I have* *motivated them in the learning of python. Most of them have come to realise that there are more careers in Physics than just medicine and engineering.''*

Comparing Zeb's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Zeb informed his students about job prospects and careers in Physics which was in agreement with what his students responded to on questions 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire.

> ***Teacher 7 (Kat):*** *''They have come to know that there are a lot of branches in Physics they can pursue and this will help them in choosing careers in Physics. With the careers in Physics, they will be able to fit into the future. They are really inspired to do Physics. Some of the students who graduated and are in SHS are now doing science and studying Physics as a subject.''*

Comparing Kat's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Kat informed her students about careers in Physics and her students were inspired to study Physics which was in agreement with what her students responded to on questions 12, 14, 16, 23, 26, 27, 28, 29, 30, 31 and 32 but was in disagreement with questions 33, 35, 36 and 37 on the student's questionnaire.

> ***Teacher 8 (Ceph):*** *''There was a time I told a parent that he should allow his child to study science at the SHS but the parent told he doesn't have money. I encouraged the parent that it is not all about money but what the child can do and do it comfortably and well. The child is now a science student and doing very well at the SHS. I have been inspiring my students to do science at the SHS by also talking to their parents that the students are good in science and therefore can offer science at SHS. Now a lot of my students after completing JHS want to offer science at the SHS and even after SHS study Physics at the university.''*

Comparing Ceph's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Ceph has been inspiring his students to offer science at the SHS and even after SHS study Physics at the university which was in agreement with what her students responded to on questions 12, 16, 26, 28, 29, 30 and 32 on the student's questionnaire.

Teacher 9 (Bunya): *''Through games the students are able to overcome the fear of Physics which has been an albatross on the neck of these students. I sometimes occasionally organize seminars, invite resource persons who have graduated with Physics from the universities, and they come to tell them more about the prospects of studying Physics. Occasionally when they open for applications for the Science Technology Mathematics & ICT Education (STME), we encourage some of our students to apply and it will amaze you that last year we had three of our students to be selected for this programme .''*

Comparing Bunya's response to that of his students' response and ith the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Bunya informed his students on the prospects in Physics and aroused their interest of studying Physics which was in agreement with what his students responded to on questions 9, 23, 25 and 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire.

Teacher 10 (Saddi): *''Engaging them in research activities by giving them certain things to research on using the internet. I organize career orientation for them to know the benefits of doing Physics/science. When science teachers meet we stressed on it that when teaching we should place emphasis on the prospects in Physics, relate the lesson to real life situations for students to understand. Some of the students are willing to study Physics at the SHS, CoE and universities. There are some students who have completed JHS and are now doing General Science at the SHS and studying Physics as a subject. More of the hands on activities has enhanced their interest in Physics.''*

Comparing Saddi's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Saddi informed his students about the benefits of doing Physics/science, the prospects in Physics, relate the lesson to real life situations for them to understand, willing to study Physics at the SHS, CoE and universities and their interest in Physics has been enhanced which was in agreement with what his students responded to on questions 6, 9, 12, 14, 16, 18, 19, 23, 25, 26, 27, 28, 29, 30, 31, 32 and 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire.

Teacher 11 (Debbie): *''I have been telling them that it is not as difficult as they think. When we talk of Physics is about everyday activities and they should try hard to study it. I have been telling them about the career opportunities as a way of inspiring them to study it at the SHS and university. I also mentioned to them the many opportunities Physics have in life.''*

Comparing Debbie's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Debbie informed her students about the usefulness of Physics in their daily lives, career opportunities and to study Physics at the SHS and university which was in agreement with what her students responded to on questions 12, 16, 23, 30 and 32 but was in disagreement with questions 33, 35, 36 and 37 on the student's questionnaire.

> ***Teacher 12 (Patty):*** *''I try to expose them to some of the areas in Physics they can explore in future. I told them the many job opportunities and other academic opportunities to pursue in Physics. At first, they didn't know the subjects to choose but now I inform them about the different types of branches in Physics. This inspires them that it is not only one subject that they will do so that if they don't get the chance to do it then they are stuck. I now use different opportunities available to inspire them so that they know that if they can't do certain subjects at least they can do Physics.''*

Comparing Patty's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Patty informed her students about the job opportunities and other academic opportunities to pursue in Physics which was in agreement with what her students responded to on questions 12, 14, 16, 23, 25, 26, 27, 28, 29, 30, 31, 32 and 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire.

> ***Teacher 13 (Wise):*** *''I have really motivated my students to get books that will engage them more and open their understanding in the area of Physics for example I have asked my students to get pdfs and apps that are Physics related rather than focusing on other things on social media because there are a lot of apps that can help them understand what is been taught in class during Physics lessons. To increase their interest, they've to be playing with these apps, study the books or pamphlets they buy, and it will give them more experience in Physics. First of all, I inspire them by introducing them to opportunities that are around. One area I have particular asked them to focus on is in the area of astronomy because it's a new area in Ghana and the opportunities in the future are promising. I tell them about what is going on at the GRAO and the need for more people who will be needed in that field.''*

Comparing Wise's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question five for DARA teachers. Wise said he want to increase his students' interest in Physics and has introduced them to opportunities that are around which was in agreement with what her students responded to on questions 9, 23, 25, and 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire.

6. **Researcher: What motivation do you give to your students for the learning of Physics?**

Teacher 1 (Gab): *''Most of them are juveniles and they find it very difficult to understand certain concepts. I personally use my money to buy Physics books and stationery or at times I will buy them a lot of things that can really motivate them, when they see there is a price tag on a question, I ask them and they know they are going to get a price at the end of the it motivates them to learn.''*

Comparing Gab's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers.

Teacher 2 (Mirek): *''I told them that we're in the era of technology and it is advancing very fast, and that Physics is the foundation of technology so they're eager to learn Physics. I inform them about the various career opportunities in Physics and they are willing to study Physics at various levels to get jobs in Physics. Lastly, I inform them that there are a lot of prospects in Physics. So my students are assiduously learning Physics to take advantage of the numerous prospects in Physics.''*

Comparing Mirek's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. Mirek said his students' were eager to learn Physics, informed them about the prospects and various career opportunities in Physics and they are willing to study Physics at various levels to get jobs in Physics which was in agreement with what his students responded to on questions 12, 14, 16, 23, 25, 26, 27, 28, 29, 30, 31, 32 and 33 but was in disagreement with questions 9, 35, 36 and 37 on the student's questionnaire.

Teacher 3 (Geo): *''The motivation is the fact that Physics attract in recent times in Ghana I told them Physics is not applied but in recent times because of the DARA project and the Kutunse telescope. Now the prospects of Physics and astrophysics is high and so people can go into it unlike before if you do*

Physics the only thing you can do with Physics is to teach but now since we have GAEC/GSSTI having Physics related courses and this astronomy courses it has become important that students can also focus on Physics.''

Comparing Geo's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. Geo informed his students' about the relevance of Physics, prospects of Physics and to focus on Physics which was in agreement with what his students responded to on questions 12, 14, 16, 18, 19, 23, 25, 26, 27, 28, 29, 30, 31, 32 and 33 but was in disagreement with questions 9, 35, 36 and 37 on the student's questionnaire.

Teacher 4 (Nesto): *''I give them tasks or assignments to create something like a model of a car or things around and base on their ability to do that I sometimes award them with certain basic things they need as student such as school uniforms, bags, textbooks etc.''*

Comparing Nesto's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers.

Teacher 5 (King): *''The motivation comes from me telling them that when you learn Physics you can be your own boss, you can build your own machines, and you can be a contractor. So, the motivation comes from the fact that there a lot of job opportunities when you study Physics.''*

Comparing King's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. King informed his students about the lot of job opportunities when they study Physics which was in agreement with what his students responded to on question 33 but was in disagreement with questions 23, 35, 36 and 37 on the student's questionnaire.

Teacher 6 (Zeb): *''I engage my students in a lot of experiments and practical. I take time to finish my lessons in class with questions and class exercises. I give them positive feedback in their answers so most of them are now confident that they can do Physics because formerly they were scared about Physics and elective maths but with the way I teach them I give them positive remarks on* *their worksheets like excellent, very good, good and they feel very proud in learning Physics.''*

Comparing Zeb's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. Zeb said his students were very proud to learn Physics which was in agreement with what his students responded to on questions 12, 14, 16, 26, 27, 28, 29, 30, 31 and 32 on the student's questionnaire.

Teacher 7 (Kat): *'' I motivate my students to study Physics which would make them creative and innovative in science. I inform them that most of the appliances we have in our various homes are based on the application of Physics. I motivate them by saying that if they study Physics very well, they can also invent new ones that can help to solve problems.''*

Comparing Kat's response to that of her students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. Kat informed her students about the relevance of studying Physics and how Physics can be used to solve problems which was in agreement with what her students responded to on questions 6, 18, 19 and 21 but was in disagreement with question 1 on the student's questionnaire.

Teacher 8 (Ceph): *''I engage them, talk to them, and use the real materials readily available to study Physics. They should not see Physics to be a difficult subject but it's all about everyday activities that we engage in and as far as people are doing it, they can also do it.''*

Comparing Ceph's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. Ceph informed his students about the relevance of studying Physics and how Physics can be useful in their daily lives which was in agreement with what his students responded to on questions 1, 18 and 19 on the student's questionnaire.

Teacher 9 (Bunya): *'I informed them about the vocations that they are likely to have when they pursue Physics further. As part of my weekly meetings with them occasionally get one or two resource persons who are* *physicists/astronomers to give them a talk. By doing this they know that when they study Physics there are more prospects. Sometimes I use the little money that comes my way to motivate them to buy some books for students that excel in Physics to serve as a source of motivation to other students who don't like Physics. Another way is when the STME clinics are opened I tell them to actually apply to be able to participate it because it is one of the prestigious programmes that students involve themselves in. I informed them that they should participate in it to enjoy the benefits of participation.''*

Comparing Bunya's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. Bunya informed his students about the relevance of studying Physics, on the prospects in Physics and aroused their interest of studying Physics which was in agreement with what his students responded to on questions 9, 18, 19, 23, 25 and 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire.

Teacher 10 (Saddi): *''Through enquiry-based learning and I also give them a Project Based Learning (PBL) and find solutions to it. A typical example is a project we did on environment, so they found solutions to the environmental challenges, and they generated solutions to it. So, I use PBL approach in the teaching and learning of Physics. I also use PBL approach, enquiry-based learning and project based learning to motivate my students to learn Physics.''*

Comparing Saddi's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers.

Teacher 11 (Debbie): *''What I normally do is that students who excel are rewarded so that those who don't excel be motivated to do their best the next time when a test is organized. So, the students who don't excel learn from those that excel to improve.''*

Comparing Debbie's response to that of her students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. Debbie's students responded that their teacher was not their main influence in liking Physics.

Teacher 12 (Patty): *''I inform them on the significance of learning Physics. I engage them in a lot of experiments or practical.''*

Comparing Patty's response to that of her students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. Patty's students responded that their teacher was not their main influence in liking Physics. Patty informed her students about the relevance of studying Physics which was in agreement with what her students responded to on question 18 on the student's questionnaire.

Teacher 13 (Wise): *''I simply tell them Physics is fun and it makes them to appreciate everything that is around them. It gives them a feel about understanding of how the universe works and understanding of how the various things we see around us operate.''*

Comparing Wise's response to that of his students' response and with the research question six and seven indicates that both were in agreement on the attitudes towards teaching Physics and on the perceptions on the relevance of studying Physics with regards to the interview question six for DARA teachers. Wise informed his students about the relevance of studying Physics which was in agreement with what his students responded to on question 18 and 19 on the student's questionnaire.

7. **Researcher: Are your students aware of the telescope in Kuntunse (Ghana Radio Astronomy Observatory, GRAO)? If ''Yes'' why and if ''No'' why?**

Teacher 1 (Gab): *''Yes they are aware of it. They are aware through our club meetings for some time we even made a prototype telescope using papers. So they are much aware that there is a telescope in Ghana, and they wish to go there and see it themselves. I showed them pictures of it and its uses.''*

Comparing Gab's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. .

Teacher 2 (Mirek): *''Yes, I always use it as an example to them and to let them know that Ghana is advancing in space technology. I always tell them that there is a radio telescope at Kutunse. When we are teaching some of the concepts are in relation to it. Typical example is the topic on gravitational fields in the syllabus related to things in the universe generally. I told them it is used* *to research some of these things in space. They have not gone on a field trip to GRAO yet, but it is in the pipeline for them to visit.''*

Comparing Mirek's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. Mirek said his students have not gone on a field trip to GRAO but it is in the pipeline for them to visit which was related to question 43 on the student's questionnaire.

> ***Teacher 3 (Geo):*** *''Yes, I have spoken to them about it, some of my students who live around and pass by it have seen the telescope but don't know its uses. From my conversation with the students, I got to know that they are aware and also those who live around Kutunse because some of my students are day students and those who use that stretch of the road mention that they have seen the telescope just that most of them still see it as a telecommunication satellite.''*

Comparing Geo's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers.

> ***Teacher 4 (Nesto):*** *''Yes, just recently we had a trip to the GRAO, and they were very fascinated about the whole structure. Some of them really love the whole environment and how it works.''*

Comparing Nesto's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. Nesto said his students have gone on a trip to GRAO which was related to question 43 on the student's questionnaire.

> ***Teacher 5 (King):*** *''Yes, they are aware, because they've been there and also gone there on a field trip last year. They know because when they went there they entered the observatory and they had a whole lot of practical and experiments. They even had hands-on activity to construct the telescope.''*

Comparing King's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. King said his students have been there which was related to question 43 on the student's questionnaire which was not significant.

> ***Teacher 6 (Zeb):*** *''Yes, I told them personally and have showed them pictures of the telescope and they want to visit it. That is the main reason I was able to convince the school for the astronomy talk which is going to happen next week and they are happy that right after the talk they are going to visit the planetarium. They are aware because I have interest in astronomy and also talk on it every day when am teaching, so they hear and they are also interested in it and curious to know more about it. I usually let them know that there are a lot of opportunities that they can tap into once they progress.''*

Comparing Zeb's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. Zeb is interested in it and his students are also interested in it and curious to know more about it and also informed them about a lot of opportunities that they can tap into once they progress which was in agreement with what his students responded to on questions 9, 18, 19, 23, 25 and 33 but was in disagreement with questions 35, 36 and 37 on the student's questionnaire. .

> ***Teacher 7 (Kat):*** *''Yes they are, I have been with them there to observe everything there. As part of the DARA programme it was an honour to be there with my students. After teaching the theory aspect of Physics to the students they visited the GRAO to practically observe things for themselves.''*

Comparing Kat's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. Kat said she has been there with her students which was related to question 43 on the student's questionnaire.

> ***Teacher 8 (Ceph):*** *''Yes, we went for a visit there by DARA and we had a lot of activities and interactions there with other DARA club members in Ghana. When we return back this informed us to construct a prototype of the GRAO.''*

Comparing Nesto's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. Ceph said he has been there with his students which was related to question 43 on the student's questionnaire.

> ***Teacher 9 (Bunya):*** *''Yes, the last time we met as patrons for the respective schools we had first-hand experience. We were promised that the students will be visiting the GRAO telescope, so during the latter part of the term last year we had the opportunity to visit the telescope at Kutunse. They are aware because I have briefed them on it, how they work, transmit information/messages from one country to another and also this cluster of telescopes that come together and their functions. They were having first-hand information about the trip so when they got there, they were really happy and they enjoyed the trip by asking different types of questions.''*

Comparing Bunya's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. Bunya said he has been there with his students which was related to question 43 on the student's questionnaire which was not significant. Bunya informed his students about the relevance of studying Physics and his students were really happy and they enjoyed the trip which was in agreement with what his students responded to on questions 9, 18, 19 and 25 on the student's questionnaire.

> ***Teacher 10 (Saddi):*** *''In fact, majority of those who completed were aware but the current students are not aware. The current students are yet to visit the place. During teaching I mention it to them just that they've not been there. They are aware through the teaching of the solar system, so when am teaching I alert them of it, and they become interested to see it''*

Comparing Saddi's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. Saddi said his students are yet to visit the place which was related to question 43 on the student's questionnaire which was not significant. Also, he mentioned that his students became interested to see it which was in agreement with what his students responded to on questions 9 and 25 on the student's questionnaire.

> ***Teacher 11 (Debbie):*** *''Yes they are aware. They've been there with the rest of other DARA/astronomy clubs in different schools. They are aware because when we came back, I discuss with them by asking them a lot of questions on what they saw, what they learnt and in their textbooks they've some topics under weather, climate and seasons so when we got there they were able to come out with some of the instruments they saw there like the wind vane etc.''*

Comparing Debbie's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. Debbie mentioned her students have been there which was related to question 43 on the student's questionnaire.

Teacher 12 (Patty): *''Yes, because I took them to the GRAO to observe it for themselves. The tour guide and the DARA/PRAGSAC team were there to explain how it operates and how various things are done there. It is very close to us, at first they didn't know what it was and they have been seeing the object there but since we visited the place they know everything about it.''*

Comparing Patty's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers. Patty mentioned that she took her students there which was related to question 43 on the student's questionnaire.

Teacher 13 (Wise): *''Yes, quite a number of them are aware. During my lessons on topics that are astronomy or astrophysics related I tell them about it. I do this because of the motivation I had through my participation in DARA.''*

Comparing Wise's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question seven for DARA teachers.

8. **Researcher: How do you use the knowledge gain from the DARA training to help your students study Physics?**

Teacher 1 (Gab): *''I have gotten enough knowledge and understanding certain basic things in life for instance when I was first teaching about light, I used to have limited knowledge I only learn using the visible region but now the knowledge has broadened. So, it has increased my understanding, so it makes my teaching very easy.''*

Comparing Gab's response to that of his students' response at Kwabenya Community SHS and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers and also comparing Gab's response to that of his students' response at GAEC Basic School and also with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers.

Teacher 2 (Mirek): *''It has helped me in the explanation of concepts. Also, my ability to relate concepts to practicality because usually if you're teaching Physics concepts to students and you're not able to give practical examples to them, the concepts becomes so abstract and they don't appreciate abstract things a lot because learning abstract things is about rote learning but if you are able to relate the concepts to practical things, especially some of the things in space that students see around and when they look into the skies they hear some of them''*

Comparing Mirek's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers.

Teacher 3 (Geo): *''During the DARA training, we did a lot of models to explain some of these concepts, so I have been using some these models for my daily needs but most of the cases am not able to get the models so it becomes very difficult so when it comes to gravitation I use some models to explain it and sometimes too I use videos online and other models to explain a concept to them.''*

Comparing Geo's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers.

Teacher 4 (Nesto): *''I have learned a lot and I use the knowledge gained to teach the students and to train them to embrace the knowledge I have acquired through the DARA training.''*

Comparing Nesto's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers.

Teacher 5 (King): *''It gives me a practical basis for teaching Physics. The knowledge I had has enabled me to teach and teach very well.''*

Comparing King's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers.

Teacher 6 (Zeb): *''I have acquired a lot of methods such as enquiry-based learning. I usually want them to be curious about space and let them understand that there are a lot of opportunities because some have tailored their minds that it's only becoming a doctor and an engineer that can make you successful in Africa and that is the only place you have availability of jobs. I told them about the SKA project and show them videos online. They have the belief that this is a pioneering field, and they need to be part of it. I always make them know more about astronomy.''*

Comparing Zeb's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers. Zeb informed his students about a lot of opportunities, prospects and jobs in Physics which was in agreement with what his students responded to on questions 9, 18, 19 and 33 but was in disagreement on questions 23, 35, 36 and 37 on the student's questionnaire.

Teacher 7 (Kat): *''The DARA has given me a lot of knowledge and made available some TLMs to use in class. Unlike before getting the phases of the moon and other objects in space like showing diagrams of the asteroids were not there for me but now with the help of the DARA TLMs, I am are able to use these materials to illustrate these things to them. After training I abreast the students with the knowledge gained concerning astronomy. I inculcated in them the knowledge I had, and this has helped them to study Physics well.''*

Comparing Kat's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers.

Teacher 8 (Ceph): *''I used the knowledge gained in teaching my students for example the globe and other TLMs they gave to us. I also made the TLMs available to other teachers for use. They use it to teach the oceans and continents. The materials are available and the few ones we have we take advantage of it in teaching.''*

Comparing Ceph's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers.

Teacher 9 (Bunya): *''It has helped me a lot as a teacher because I always have the phobia for Physics, so even sometimes when am teaching the*

Physics I always want to swerve the aspect of Physics and teach more on biology aspect. I'm able to teach with ease and this is having a ripple effect on the students I teach and now a lot of my students are doing well in Physics.''

Comparing Bunya's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers. Bunya mentioned that his students are doing well which was in agreement with what his students responded to on question 23 on the student's questionnaire.

> ***Teacher 10 (Saddi):*** *''I organize Physics programmes in my school to help my students to learn Physics. I also do what we call time with the coordinator, where I meet any class then perform hands-on activities with them by organizing my materials and perform various activities with them especially the Physics areas where my students normally have problems and teachers don't use hands-on activities to explain basic concepts in Physics when teaching, so during the time with the coordinator I do these activities. I also have the subject briefing, so during that time too I use the knowledge on hands-on activities learned from DARA to explain basic concepts in Physics where my students have challenges for them to understand the concepts easily and for the teachers through workshops, I normally organize for them. I also normally visit the schools within my area of jurisdiction and whenever I visit, I use the knowledge to explain problems they have in Physics by using hands-on activities.''*

Comparing Saddi's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers. Saddi mentioned that his students were willing to learn Physics and explain basic concepts in Physics where his students have challenges for them to understand the concepts easily which was in agreement 7, 12, 14, 16, 18, 19, 23, 25, 26, 27, 28, 29, 30, 31, and 32 on the student's questionnaire.

> ***Teacher 11 (Debbie):*** *''The science syllabus for them doesn't cover much so at the club session we do more on the topics in Physics. During the training, we were given some materials to help us teach the students very well. I have been using these materials to teach my students and when they have difficulties in using the materials, I meet them during break to further explain or do that during the club meetings or even after school.''*

Comparing Debbie's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers. Debbie mentioned that she has been using some materials to teach her students when they have difficulties which her students were in both agreement and disagreement on the student's questionnaire.

> ***Teacher 12 (Patty):*** *''Because now the teaching have been fun, as they practice they become very happy and enjoy studying Physics. It has helped me in enhancing my teaching and given them more information on Physics. The DARA has exposed me to the opportunities that I can explore, the process of exploring those opportunities and the activities I can use in teaching. Now I have been exhibiting all these and the students are more involved in the teaching and learning process.''*

Comparing Patty's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers. Patty mentioned that her students become very happy and enjoy studying Physics which was in agreement to question 25 and disagreement to question 9 on the student's questionnaire.

> ***Teacher 13 (Wise):*** *'I used the knowledge gained to explain Physics concepts in simpler ways for my students to understand during Physics lessons. My students are now much interested in Physics and would like to do Physics at the university.''*

Comparing Wise's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for DARA teachers. Wise mentioned that his students were now much interested in Physics and would like to do Physics at the university, which was in agreement to question 9, 16, 25, 28, 29 and 32 on the student's questionnaire.

9. **Researcher: What are your perceptions about careers that involve Physics?**

> ***Teacher 1 (Gab):*** *''Careers related to Physics are somewhat quite technical that you have to be well equipped with the technical knowhow and the skills to be able to execute them.''*

Comparing Gab's response to that of his students' response at Kwabenya Community SHS and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers and also comparing Gab’s response to that of his students’ response at GAEC Basic School and also with the research question seven indicates that his students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

> ***Teacher 2 (Mirek):*** *''I think they are rewarding and fulfilling careers because Physics gives you a lot of opportunities when it comes to careers from mechanics, electronics, engineering, nuclear. Physics exposes you to a lot of careers one can get. Physics careers are very good that students should be encouraged to pursue.''*

Comparing Mirek’s response to that of his students’ response and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

> ***Teacher 3 (Geo):*** *''The careers in Physics personally and based on observation in Ghana if Physics related jobs are not available so if you do Physics you seem to be limited with the exception of branching into engineering and all that. The job prospects are not readily available in Ghana as compared to other countries.''*

Comparing Geo’s response to that of his students’ response and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

> ***Teacher 4 (Nesto):*** *''I think that they are very welcoming, and they have a lot to offer because they are very challenging. They challenge us to be on our toes to know more about our world and the environment. The only challenge is that sometimes due to some financial constraints some people may not have the support from the home to undertake it, but I think it has a lot to offer which all of us must embrace.''*

Comparing Nesto’s response to that of his students’ response and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

> ***Teacher 5 (King):*** *''Most people think Physics is a mystery subject but now everything is clear. Five of the students are now studying Physics and other Physics related subjects at the SHS. They see Physics as a daily subject, a subject they can embrace easily.''*

Comparing King's response to that of his students' response and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers. King mentioned that his students were now studying Physics and other Physics related subjects at the SHS which was in agreement with questions 12, 26 and 30 on the students' questionnaire.

> ***Teacher 6 (Zeb):*** *''I think is a very good field. Although we don't have a lot of institutions in Africa and Ghana that operate in Physics or uses Physics like GAEC, Council for Scientific and Industrial Research (CSIR). There are also a lot of places that uses Physics and that skills and knowledge I Physics will be needed. I make them know that the global way of doing things and that careers in Physics are very important. They are always online looking at particle Physics, CERN, what is happening in particle Physics, nanotechnology etc. my students are aware of a lot of careers in Physics. The school gave me a platform to talk on science careers to all science students. A lot of the students know a lot of careers in Physics.''*

Comparing Zeb's response to that of his students' response and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

> ***Teacher 7 (Kat):*** *''Physics is a branch of science, and it deals with energy and its effect. Without energy the earth will not be in existence. The sun is one reason the earth is available, and the energy of the sun can be used to do a lot. Astronomy is one of the careers, ICT just to mention a few and a whole lot of careers.''*

Comparing Kat's response to that of her students' response and with the research question nine indicates that her students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

> ***Teacher 8 (Ceph):*** *''There are thousands of job opportunities out there that we might not know or my students are not aware of. That's why they normally say if they study Physics, they won't get a job. There are a lot of job opportunities at the GRAO, and students have to be aware of it and help them to further their education in science.''*

Comparing Ceph's response to that of his students' response and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

> ***Teacher 9 (Bunya):*** *''The careers are prestigious and Physics is the future of this world. We have a maxim/slogan of the DARA in my school which reads ''the future of this world is in my school'', so anytime we kick start our club activities/meetings and teaching I will say the ''future of this world'' and the students will respond ''it's in my school''. We say in my school because we see that Physics is the future of this world and so if students are now beginning to like the teaching and learning of Physics.''*

Comparing Bunya's response to that of his students' response and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers. Bunya mentioned that his students were now beginning to like the teaching and learning of Physics which was in agreement with questions 9 and 25 on the students' questionnaire.

> ***Teacher 10 (Saddi):*** *''They are careers that are good, but the only thing is that they are not all that aware of the various careers in Physics. When we encourage our students to take up these careers it will be to their own advantage, and it will be very fine.''*

Comparing Saddi's response to that of his students' response and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

> ***Teacher 11 (Debbie):*** *''I think that when you have an in-depth knowledge in Physics you will be able to get a particular career. Physics is a very good subject and when you're able to pursue it very well you get a whole lot of careers from it. This broadens your mind, and it gives you in-depth knowledge about the universe and how to live in it.''*

Comparing Debbies's response to that of her students' response and with the research question nine indicates that her students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

> ***Teacher 12 (Patty):*** *''My thinking about careers in Physics is that it makes you very observant in life. In fact, it helps the individual who pursues Physics to improve other aspects of his/her life because it will make you very prudent in doing things and you will become more critical about things.''*

Comparing Patty's response to that of her students' response and with the research question nine indicates that her students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers. Patty mentioned that Physics makes one very observant in life, improves life and makes one become more critical about things which was in agreement with her students' response on question 4 but in disagreement with question 1 on the students' questionnaire.

Teacher 13 (Wise): *''Over the years in Ghana much attention is not paid to the studying of Physics because of the perception that after studying Physics the only thing you end up doing is teaching. But for me, I have realised from DARA that there are other areas you can apply the knowledge in Physics, not only in astronomy or astrophysics but it can lead you to work at observatories, research institutions and not only end up been in the classroom.''*

Comparing Wise's response to that of his students' response and with the research question nine indicates that some students were in agreement and disagreement on the knowledge of career routes in Physics with regards to the interview question nine for DARA teachers.

10. **Researcher: What are your perceptions about the relevance of studying Physics?**

Teacher 1 (Gab): *''If you study Physics you try to satisfy your own as I said somewhat is also a philosophy so you satisfy certain things troubling the mind blowing questions about the universe and certain things itself and apart from that you also increase your knowledge base for creativity and innovation and in terms of job prospects are on a high demand because it appears that most of the industries here in Ghana and outside Ghana employs Physics as a foundation so I think on average you equip yourself with the basics in life.''*

Comparing Gab's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Gab said job prospects in Physics were on high demand and Physics is useful in our daily lives which was in agreement with what his students at Kwabenya Community SHS responded on questions 1, 23 and 33 but was in disagreement on questions 35, 36 and 37. Also, Gab was in agreement with what his students at GAEC

Basic School responded on questions 23 but was in disagreement on questions 1, 33, 35, 36 and 37 on the students' questionnaire.

> ***Teacher 2 (Mirek):*** *''If you study Physics, it helps you appreciate the environment because there are so many things around us that are Physics based. Physics will enable you to have a rewarding career. The training that the study of Physics gives builds you academically that is your numeracy skills develops your critical thinking, develops your application skills, so Physics builds you as an academician. It is very relevant, even for people who don't have Physics careers, studying Physics will prepare them and make them ready for any academic venture they will like to be involved in.''*

Comparing Mirek's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Mirek said Physics will enable you to have a rewarding career, builds you academically that is your numeracy skills, develops your critical thinking and develops application skills which was in agreement with what his students responded on questions 4, 23 and 33 but was in disagreement on questions 35, 36 and 37 on the student's questionnaire.

> ***Teacher 3 (Geo):*** *''If you study Physics it helps you to understand the other science related topics or courses. It also increases your analytical thinking and thoughts. It makes you much determined and hardworking. Physics disciplines you as a student, makes your mind very matured and ability to think and analyse things critically.''*

Comparing Geo's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Geo mentioned that Physics increases one's analytical thinking and thoughts which was in agreement with what his students responded on questions 4 on the students' questionnaire.

> ***Teacher 4 (Nesto):*** *''Physics is very important because there is nothing within our environment that does not involves Physics. The more we understand Physics the more we can explain things that happens, the houses we build, the cars we see it is very significant to study Physics. It helps us to understand our world better and to embrace it and make the necessary changes to bring about improvement, development and technological advancements.''*

Comparing Nesto's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Nesto said that Physics is useful in our daily lives which was in agreement with what his students responded on questions 1 on the students' questionnaire.

> ***Teacher 5 (King):*** *''The mystery surrounding Physics is no more after the training. Physics is very important and therefore urge every individual and school to take the teaching and learning of Physics to be very serious because it opens doors.''*

Comparing King's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers.

> ***Teacher 6 (Zeb):*** *''Apart from helping us in our day-to-day activities or making us to think about the simple way of doing things like teaching my kids on frictional forces and how to design pulleys and inclined planes to solve problems. Everybody have to study it even if it is not a subject that you have to study due to the role that it plays in science. Everybody needs to understand a bit of Physics for his or her own daily living.''*

Comparing Zeb's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Zeb said that Physics is useful in our daily lives and used to solve problems which was in agreement with what his students responded on questions 6 and 21 but was in disagreement with question 6 on the students' questionnaire.

> ***Teacher 7 (Kat):*** *''Studying Physics is like studying nature. It involves energy. All the types of energy. There are a lot of things that have been left dormant and have not been used that can be made useful. Studying Physics will help you discover more, acquire knowledge, research more and do more practical to solve human problems. So, I believe there are a lot and it's very relevant to study Physics. ''*

Comparing Kat's response to that of her students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Kat said Physics is useful in our daily lives and used to solve problems which was in agreement with what her students responded on questions 6 and 21 but was in disagreement with question 1 on the students' questionnaire.

> ***Teacher 8 (Ceph):*** *''Life itself can never exist without Physics from my point of view and life without Physics is no life. Everything we do in our daily lives is all Physics. As am talking now I am using Physics, the way we eat, putting of food into the mouth is all Physics, walking is Physics so we can't take away Physics from our daily lives.''*

Comparing Ceph's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Ceph mentioned that Physics is useful in our daily lives which was in agreement with what his students responded on question 1 on the students' questionnaire.

> ***Teacher 9 (Bunya):*** *''For the relevance is numerous. Like the maxim ''we have the future of this world'' actually falls on Physics in a sense that virtually everything we do is centred on Physics for example new set of cars coming into the world, how technology is advancing very fast, and all these are as a result of the teaching and studying of Physics. We should still go on to encourage our students to study Physics because Physics is the backbone of technology, which is advancing at a faster rate. This is the more reason I have taken upon myself to ensure that my students won't trail the path that I did so that they will become very good physicists and even appreciate the technology and the world in which they live.''*

Comparing Bunya's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Bunya mentioned that students should be encouraged to study Physics which was in agreement with what his students responded on questions 9 and 25 on the students' questionnaire.

> ***Teacher 10 (Saddi):*** *''I know Physics concepts are used to explain real-life situations. For example, natural occurrences. We use Physics in our daily lives for survival. We use it to solve real life problems daily.''*

Comparing Saddi's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Saddi mentioned that Physics is useful in our daily lives and used to solve real life problems which was in agreement with what his students responded on questions 1, 6 and 21 on the students' questionnaire.

> ***Teacher 11 (Debbie):*** *''Physics gives you so many opportunities, so many careers and it enlightens you about the universe.''*

Comparing Debbie's response to that of her students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Debbie mentioned that Physics gives so many careers which was in agreement with what her students responded on question 23 but was in disagreement on questions 33, 35, 36 and 37 on the students' questionnaire.

> ***Teacher 12 (Patty):*** *''When you study Physics you will have a very bright future, a very good job to do and it also exposes the person to understand so many things that goes around us.''*

Comparing Patty's response to that of her students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers. Patty said that Physics gives a very bright future, a very good job to do and useful in our daily lives which was in agreement with what her students responded on question 19, 23 and 33 but was in disagreement on questions 1, 35, 36 and 37 on the students' questionnaire.

> ***Teacher 13 (Wise):*** *''I first found the ability to find out how nature works and how the various systems in the universe interrelate, the forces of attraction and how things we didn't know before for example the recent discovery about the black hole. Physics have been able to prove and verify our long-held perception of the existence of the black hole. It has also made me appreciate the heavenly bodies and how they interrelate with each other. It was through the DARA programme that I got to know that stars get born and they also die.''*

Comparing Wise's response to that of his students' response and with the research question nine indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for DARA teachers.

5.2.1 Extracts of Non-DARA Teachers

Eight Non-DARA teachers were interviewed that was seven men and two women. Eight questions were asked on RQ6, one question was asked on both RQ7 and RQ8 for each teacher. All the questions asked were based on the RQs. This is seen in the extracts below:

1. **Researcher: Are you aware of the DARA project in Ghana? If ''Yes'' why and if ''No'' why?**
2. **Researcher: If response to question 1 is ''Yes'' - What do you think about it? If ''No'', what awareness do you know?**

Teacher 1 (Esh): ''*Yes, because it is related to satellite communication, an astronomical work including radio and transmissions.''*

Teacher 1 (Esh): *''I think it is going to help the nation a lot in the transmission of information and a whole lot, communication we are having access to certain things based on the DARA training.''*

Teacher 2 (Freda): ''*Basically No. because I have not heard of it.''*

Teacher 2 (Freda): *''I only became aware when you ask me to participate in the project.''*

Teacher 3 (Maurice): ''*No, I'm not aware. Because I was not aware this project is going on in Ghana. Today that I heard it from you that this project was going on in Ghana, so it has also boost my morale so that I will also try to help my students to study of Physics so that they can get access into the project that is going on.''*

Teacher 3 (Maurice): ''*No, just now that I have gotten the information that this is what is going on in Ghana.''*

Teacher 4 (Elis): *''Yes, I just heard a bit about it, some argument came up between my colleagues about courses to pursue.''*

Teacher 4 (Elis): *''It is about the development of radio astronomy on the minds of Africans.''*

Teacher 5 (Bismaro): *''Yes, because the time that they brought it or they commissioned it and I was listening to news on TV so I saw everything so am aware of it.''*

Teacher 5 (Bismaro): *''I think it's nice because they are trying to help the incoming students, I mean the younger ones so that they will be familiar or they will engage in the astronomy and the Physics so I think it's very good.''*

Teacher 6 (Hannab): *''No, I have not heard anything about it, I don't know, even if I have heard something it is just a flash not a detailed thing.''*

Teacher 6 (Hannab): *''I don't know of any awareness.''*

Teacher 7 (Aaro): *''No, because the type of Physics that we do in the basic school is integrated with other aspects of science. So, we don't focus much on that area.''*

Teacher 7 (Aaro): *''I learnt something about telescopes in SHS.''*

Teacher 8 (Chant): *''No, I just move to Komenda. In Kumasi we were not having this astronomy clubs there so I didn't know anything about it back then, am hearing it for the first time.''*

Teacher 8 (Chant): *''No please.''*

3. **Researcher: Would you like to be part of the DARA basic training in astronomy in Ghana? If ''Yes'' why and if ''No'' why?**
4. **Researcher: Would you like to be part of the DARA outreach team in Ghana? If ''Yes'' why and if ''No'' why?**

   The teachers interview questions three and four were deemed to not answer the RQ7, so were excluded from the analysis.
5. **Researcher: Has there been a change in the attitudes of the students you teach towards Physics? If ''Yes'' why and if ''No'' why?**

Teacher 1 (Esh): *''Yes, because sometimes when I take them through some practical they are happy with it.''*

Comparing Esh's response to that of his students' response and with the research question six indicates that his students were in disagreement on attitudes towards teaching Physics with regards to the interview question five for Non-DARA teachers.

Teacher 2 (Freda): *''There is always a stigma due to lack of resources that will help us to teach, there is a stigma on it. Pupils are afraid of learning Physics and even the sciences and so there is no change, with time and a lot of resources I think their interest will be developed.''*

Comparing Freda's response to that of his students' response and with the research question six indicates that both were in agreement on attitudes towards teaching Physics with regards to the interview question five for Non-DARA teachers.

Teacher 3 (Maurice): *''Yes, at first they take science to be a very difficult subject to them but since I came to the school students have interest in the science and due to that it has changed the subject teaching in this school and my students studying of science, there is a change in the study of science because nowadays they have taken Physics not as a difficult subject to.''*

Comparing Maurice's response to that of his students' response and with the research question six indicates that his students were in disagreement on attitudes towards teaching Physics with regards to the interview question five for Non-DARA teachers.

Teacher 4 (Elis): *''Yes, I think when we consider a topic like forces, we talk about a lot on forces, and they are improving. The understanding of the concepts has improved, based on the exercises, tests and exams conducted there has been a change and they now understand Physics.''*

Comparing Elis's response to that of his students' response and with the research question six indicates that his students were in disagreement on attitudes towards teaching Physics with regards to the interview question five for Non-DARA teachers. Elis mentioned that his students understanding of the concepts has improved, based on the exercises, tests and exams conducted and there has been a change and they now understand Physics which was in agreement with what his students responded on questions 24 and 25 on the students' questionnaire.

Teacher 5 (Bismaro): *''Yeah, of course sometimes I will say ''Yes'' and sometimes I will say ''No'' because I am teaching integrated science and integrated science is comprise of Phy, Bio, Chem and Agric but most of the time averagely my students I am teaching now they are about 24 for JHS 3 but as for the JHS 2 if I average I could see that sometimes how the students answer the Physics questions in fact is very nice but sometimes too most of them how they answer sometimes they will not even touch it at all. It means some like Physics, some also do not like Physics as compared to the previous years that the previous students I have taught, so I can say that the current JHS like the subject.''*

Comparing Bismaro's response to that of his students' response and with the research question six indicates that his students were in disagreement on attitudes towards teaching Physics with regards to the interview question five for Non-DARA teachers. Bismaro said that his students like Physics which was in agreement with what his students responded on questions 25 on the students' questionnaire.

Teacher 6 (Hannab): *''Yes, some have positive attitude and some have negative attitude. Those with the positive attitude ought for their level of understanding of the concepts and further readings they do and those with negative attitude because of the lack of the exposure they don't like reading or research for more information and one thing I see that in teaching of the concept some terminologies scare them.''*

Comparing Hannab's response to that of her students' response and with the research question six indicates that her students were in disagreement on attitudes towards teaching Physics with regards to the interview question five for Non-DARA teachers.

> ***Teacher 7 (Aaro):*** *''I will say 'yes' and say 'no' because some of the students are motivated to even learn more whiles some always lag. Some of them have interest in the subject, others they don't have interest in the subject, and I think the main reason is that we don't have the equipment so most times do improvisation and the rest. I think some think science is a difficult subject or challenging, some of us as we grew up, we also have that idea but as progress we saw it was not like that, so I think with time everything will be alright.''*

Comparing Aaro's response to that of his students' response and with the research question six indicates that his students were in disagreement on attitudes towards teaching Physics with regards to the interview question five for Non-DARA teachers. Aaro mentioned that some of his students like and dislike Physics but from what his students responded on questions 25 on the students' questionnaire shows that they were interested in Physics.

> ***Teacher 8 (Chant):*** *''Yes, because of the methods I have been using to teach them.''*

Comparing Chant's response to that of her students' response and with the research question six indicates that her students were in disagreement on attitudes towards teaching Physics with regards to the interview question five for Non-DARA teachers.

6. **Researcher: How do you inspire your students to engage with Physics learning and to further study Physics in the Senior High Schools / Universities / Colleges of Education / Polytechnics etc?**

> ***Teacher 1 (Esh):*** *''I have been telling them a lot about science, I told them studying science even naturally makes you smart, understand the world that you live in. Aside that, we have so many job opportunities. Nowadays, everything is science like I said. Apart from this when I was in SHS we the science students we were pampered because it was not a programme we were interested to do, people saw us to be brilliant and very smart, so I will be happy to see most of my students studying science to become doctors.''*

Comparing Esh's response to that of his students' response and with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question five for Non-

DARA teachers. Esh mentioned that some of his students like and dislike Physics but from what his students responded on questions 25 on the students' questionnaire shows that they were interested in Physics.

> ***Teacher 2 (Freda):*** *''I inspire them by telling them about the job opportunities, I mean the benefits they will get when they are able to go through with Physics. It has a lot of job opportunities. By doing Physics you have a broaden field to go with, I mean you can have a lot of careers.''*

Comparing Freda's response to that of his students' response and with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question five for Non-DARA teachers. Freda informed his students about the relevance of studying Physics, the job prospects and careers in Physics which was in agreement with what his students responded on questions 19, 23 and 33 but in disagreement with questions 35, 36 and 37 on the students' questionnaire.

> ***Teacher 3 (Maurice):*** *''I use apparatus during experiments so my students can get more understanding in Physics. This helps them to have interest in Physics. Physics involves a lot of careers, so my way of inspiring them I inform them that Physics is important. I told them to learn Physics very well and they can have a career in it.''*

Comparing Maurice's response to that of his students' response and with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question five for Non-DARA teachers. Maurice mentioned that his students have interest in Physics and informed them about the job prospects and careers in Physics which was in agreement with what his students responded on questions 9, 23, 25 and 33 but in disagreement with questions 35, 36 and 37 on the students' questionnaire.

> ***Teacher 4 (Elis):*** *''I think when we talk about Physics it is the study of matter and energy. The production of machines and other products uses Physics. For creativity in all these machines you need to learn Physics. In the course of teaching, I tell them all these things so if they are interested, they can study Physics in SHS, CoE and university.''*

Comparing Elis's response to that of his students' response and with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question five for Non-DARA teachers. Elis mentioned that his students have interest in Physics and can study

Physics in SHS, CoE and university which was in agreement with what his students responded on questions 9, 12, 14, 16, 25, 26, 27 and 28 but in disagreement with questions 29, 30, 31 and 32 on the students' questionnaire.

> ***Teacher 5 (Bismaro):*** *''I inspire them by trying to explain some of the areas that if you learn Physics they will have a lot of careers like engineer, pilot, and doctor. I inform them that if they pursue Physics at the SHS, CoE and university and their future will be very bright.''*

Comparing Bismaro's response to that of his students' response and with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question five for Non-DARA teachers. Bismaro informed his students about a lot of careers in Physics and to pursue Physics at the SHS, CoE and university which was in agreement with what his students responded on questions 12, 14, 16, 23, 27, 28 and 33 but in disagreement with questions 29, 30, 31, 32, 35, 36 and 37 on the students' questionnaire.

> ***Teacher 6 (Hannab):*** *''I inspire them by telling them that they should have the zeal and if they get the chance to study Physics at the SHS they will get the exposure more and have the more interest.''*

Comparing Hannab's response to that of her students' response and with the research question seven indicates that her students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question five for Non-DARA teachers. Hannab told her students to study Physics at the SHS and to have more interest in it which was in agreement with what her students responded on questions 9, 12, 25 and 26 but in disagreement with questions 29 and 30 on the students' questionnaire.

> ***Teacher 7 (Aaro):*** *''I first and foremost right from JHS 1 I just demystify that idea that science as a subject is difficult so through that I try to inspire them from time to time and I also have a group of students that I mentor. I identify students, I quiet remember last year the batch which completed I identify some of them maybe been a science teacher I told them to pursue science at SHS and three of them, two guys and one girl are pursuing science at SHS, so I identify them then I motivate them to learn Physics. I have one of my students who has completed CoE and now at the University of Cape Coast doing science.''*

Comparing Aaro's response to that of his students' response and with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question five for Non-

DARA teachers. Aaro told his students to pursue Physics at the SHS, CoE and university which was in agreement with what his students responded on questions 12, 14, 16, 27 and 28 but in disagreement with questions 29, 30, 31 and 32 on the students' questionnaire.

> ***Teacher 8 (Chant):*** *''When you teach abstractly, they will not get the understanding so mostly my teaching is based on practical work. I always tell them that the Physics they are learning here is the basics and that they will do the advance ones at the SHS, CoE and universities.''*

Comparing Chant's response to that of her students' response and with the research question seven indicates that her students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question five for Non-DARA teachers.

7. **Researcher: What motivation do you give to your students for the learning of Physics?**

> ***Teacher 1 (Esh):*** *''I do a lot of practical with them and when they see these thing,s they are very happy. I quiet remember sometimes I constructed a small telescope for them use it to see something beyond their reach and they were happy, and I even relate that to those in submarines.''*

Comparing Esh's response to that of his students' response and with the research question six and seven indicates that his students were in disagreement on attitudes towards Physics and the perceptions on the relevance of studying Physics with regards to the interview question seven for Non-DARA teachers. Esh said he constructed a small telescope for his students to see and they became happy which was in agreement with what his students responded on questions 9, 25 and 39 on the students' questionnaire.

> ***Teacher 2 (Freda):*** *''When you do Physics there is no where you cannot work and there is nothing you cannot do, it broadens the knowledge of a person, and it helps man to become a total man.''*

Comparing Freda's response to that of his students' response and with the research question six and seven indicates that his students were in disagreement on attitudes towards Physics and the perceptions on the relevance of studying Physics with regards to the interview question seven for Non-DARA teachers. Freda mentioned the relevance of Physics to his students which was in agreement with what his students responded on questions 18 and 19 on the students' questionnaire.

Teacher 3 (Maurice): *''The motivation I give to my students is that in the teaching of Physics at times I come along with items which has been developed by scientists and tell them that due to the study of Physics look at where these people are, so the role models serves as motivation to them.''*

Comparing Maurice's response to that of his students' response and with the research question six and seven indicates that his students were in disagreement on attitudes towards Physics and the perceptions on the relevance of studying Physics with regards to the interview question seven for Non-DARA teachers. Maurice mentioned the relevance of Physics to his students which was in agreement with what his students responded on questions 18 and 19 on the students' questionnaire.

Teacher 4 (Elis): *''My motivation is that in the study of Physics there are certain acquired skills you make use of examples making of cars, mobile phones and modern computerised materials, so if they learn Physics, they will be able to do all these things.''*

Comparing Elis's response to that of his students' response and also with the research question six and seven indicates that his students were in disagreement on attitudes towards Physics and the perceptions on the relevance of studying Physics with regards to the interview question seven for Non-DARA teachers. Elis informed his students about the relevance of Physics which was in agreement with what his students responded on questions 18 and 19 on the students' questionnaire.

Teacher 5 (Bismaro): *''I motivate them by giving them Physics questions to solve and whoever answers all of them correctly is rewarded by buying a gift, a special pen, book, or notebook. This has made my students to always study Physics and get a reward.''*

Comparing Bismaro's response to that of his students' response and with the research question six and seven indicates that his students were in disagreement on attitudes towards Physics and the perceptions on the relevance of studying Physics with regards to the interview question seven for Non-DARA teachers. This question was related to question 11 which was not significant.

Teacher 6 (Hannab): *''In the class, we just praise for the one who does well. Last year, those who completed someone had grade 1 in science it was just unfortunate such a person selected General Arts so did not do science but someone who had grade 2 in science is doing science at the SHS, so have few of them doing science at the SHS and some of the students here are also want to do science at the SHS as their elective subjects.''*

Comparing Hannab's response to that of her students' response and with the research question six and seven indicates that her students were in disagreement on attitudes towards Physics and the perceptions on the relevance of studying Physics with regards to the interview question seven for Non-DARA teachers. Hannab told her students to study Physics at the SHS which was in agreement with what her students responded on questions 12 and 26 but in disagreement with questions 29 and 30 on the students' questionnaire.

> ***Teacher 7 (Aaro):*** *''I tell them it is not difficult. I told them Physics is one of the easiest elective subjects in SHS just that you need time and you have to be good in maths because most of the topics is maths based so I give them a whole lot of encouragement and inspiration.''*

Comparing Hannab's response to that of her students' response and with the research question six and seven indicates that her students were in disagreement on attitudes towards Physics and the perceptions on the relevance of studying Physics with regards to the interview question seven for Non-DARA teachers.

> ***Teacher 8 (Chant):*** *''I make sure in every topic they understand it very well before moving to the next topic. Any question they ask I make sure I answer it perfectly so that they will see the interest in Physics.''*

Comparing Chant's response to that of her students' response and with the research question six and seven indicates that her students were in disagreement on attitudes towards Physics and the perceptions on the relevance of studying Physics with regards to the interview question seven for Non-DARA teachers. Chant mentioned that her students have shown interest in Physics which was in agreement with what her students responded on questions 9 and 12 on the students' questionnaire.

8. **Researcher: Are your students aware of the telescope in Kuntunse (Ghana Radio Astronomy Observatory, GRAO)? If ''Yes'' why and if ''No'' why?**

> ***Teacher 1 (Esh):*** *''I can't say yes, I haven't gone there. I can't tell, I think am the one who have to bring their mind on those things even though some are doing their private studies I can't tell if some of them are aware of it. I have not informed them and I have not gone there.''*

Comparing Esh's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for Non-DARA teachers.

> ***Teacher 2 (Freda):*** *''Yes, somehow because we use to watch them on TV but for the site we have not been there before. In JHS 1, we learned about the pin-hole camera, the camera, telescope etc.''*

Comparing Freda's response to that of his students' response and with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for Non-DARA teachers. Freda mentioned that his students have learned about the telescope which was in agreement with what his students responded on question 39 on the students' questionnaire.

> ***Teacher 3 (Maurice):*** *''No, because it was just this morning I got to know of that there is a telescope in Ghana.''*

Comparing Maurice's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for Non-DARA teachers.

> ***Teacher 4 (Elis):*** *''No, the thing is my school is basic school and we don't do all these things. I have no awareness.''*

Comparing Elis's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for Non-DARA teachers.

> ***Teacher 5 (Bismaro):*** *''Yes, they are aware of it and even last three days they wrote science exams and one of their test of practical I gave them a question under telescope which was taught in class. During the lesson I asked them about the commissioning of the telescope and the answers I got means they are aware.''*

Comparing Bismaro's response to that of his students' response and with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for Non-DARA teachers. Bismaro said that his students have learned about the telescope which was in agreement with what his students responded on question 39 on the students' questionnaire.

Teacher 6 (Hannab): *''No, I have already told you that I don't know so I have never inform them in the class and I don't have any article on it so I have not given any information to my students.''*

Comparing Hannab's response to that of her students' response and also with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for Non-DARA teachers.

Teacher 7 (Aaro): *''Yes, they are aware as current affairs they are aware from social studies that there is a telescope at Kutunse.''*

Comparing Aaro's response to that of his students' response and with the research question seven indicates that his students were in disagreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for Non-DARA teachers. Aaro said that his students have learned about the telescope which was in agreement with what his students responded on question 39 on the students' questionnaire.

Teacher 8 (Chant): *''Yes they are, because some of them have been there before so they knew of it.''*

Comparing Chant's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question eight for Non-DARA teachers.

9. **Researcher: What are your perceptions about careers that involve Physics?**

Teacher 1 (Esh): *''Some time ago, I was telling them if you want to be a very good driver you need to know a little bit of Physics because on your way somewhere something may happen and you will be stranded and if you know a little bit about Physics you will help yourself whereby nobody will help you. Is very beautiful to be an astronaut in fact it is very beautiful, so careers that is related to Physics I like them very much.''*

Comparing Esh's response to that of his students' response and with the research question eight indicates that his students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for Non-DARA teachers. Esh informed his students about the relevance of Physics which was in agreement with what his students responded on questions 18 and 19 on the students' questionnaire.

> ***Teacher 2 (Freda):*** *''I don't have any negative perceptions. They are very positive in a sense that in my education I learnt a lot in Physics. I have interest in Physics, because by doing Physics I am a teacher and using my Physics to teach, others can use it to become a doctor or nurse, so it's very good.''*

Comparing Freda's response to that of his students' response and with the research question eight indicates that his students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for Non-DARA teachers.

> ***Teacher 3 (Maurice):*** *''At the end of the day we get paid (salary) from the careers that involves Physics and it also opens our mind a lot, exposes us to the environment how things are''.*

Comparing Maurice's response to that of his students' response and with the research question eight indicates that his students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for Non-DARA teachers.

> ***Teacher 4 (Elis):*** *''I think there are nice careers in Physics and if one take advantage of them, there are a lot of skills one can get.''*

Comparing Elis's response to that of his students' response and with the research question eight indicates that his students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for Non-DARA teachers.

> ***Teacher 5 (Bismaro):*** *''Job opportunities in Physics like medical lab technologist, I use to tell them that medical lab technologist fall under physical science so if they learn Physics they can become one. I told them they can become a pilot which is a very good career.''*

Comparing Bismaro's response to that of his students' response and with the research question eight indicates that his students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for Non-DARA teachers.

> ***Teacher 6 (Hannab):*** *''With the careers when you engage in a subject like Physics we have a lot of importance. Teaching of Physics in the various level of*

education we use it, then nurses, doctors, drivers, carpenters and even contractors all use the Physics.''

Comparing Hannab's response to that of her students' response and with the research question eight indicates that her students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for Non-DARA teachers. Hannab informed her students about the relevance of Physics which was in agreement with what her students responded on questions 18 and 19 on the students' questionnaire.

Teacher 7 (Aaro): *''I know something like astronomy, but in Ghana here pursuing Physics and having a career is very difficult as in the availability of jobs but when my students want to pursue Physics at SHS what I tell them is that be ready to teach after doing the Physics so normally encourage them to do Physics or science education so that when they come and they don't get a job they can teach because in Ghana as you know doing Physics as a course and getting a job is very difficult. I had wanted to do mechanical engineering but I have to divert into education.''*

Comparing Aaro's response to that of his students' response and with the research question eight indicates that his students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for Non-DARA teachers. Aaro informed his students that having a career was very difficult as in the availability of jobs which was in disagreement with what his students responded on question 23 on the students' questionnaire.

Teacher 8 (Chant): *''It helps you to know a lot of things in life. It helps you to know about a whole lot of things as compared to someone with no knowledge in Physics.''*

Comparing Chant's response to that of her students' response and with the research question eight indicates that her students were in disagreement on the knowledge of career routes in Physics with regards to the interview question nine for Non-DARA teachers. Chant informed her students about the relevance of Physics which was in agreement with what her students responded on questions 18 and 19 on the students' questionnaire.

10. **Researcher: What are your perceptions about the relevance of studying Physics?**

__Teacher 1 (Esh):__ ''I will say it is one thing you can never do away with. Everything we do is related to Physics, measuring, motion, invention of cars, engineering you can't do away with.''

Comparing Esh's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for Non-DARA teachers. Esh said everything we do is related to Physics which was in disagreement with what his students responded on question 1 on the students' questionnaire.

__Teacher 2 (Freda):__ ''They are positive, very positive because it may help one to acquire more knowledge and even how to get money, and everything.''

Comparing Freda's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question three for Non-DARA teachers.

__Teacher 3 (Maurice):__ ''It equips the students' knowledge, it also opens their mind to electronics, engineering, and even our electricity because most of my students don't know anything about their home appliances but with the study of Physics they are able to know the dangers of using it and it is the Physics that opens their mind about those electrical appliances, so it is very important so if they get to know that it is not advisable to play with electricity. So when you give them this information and they go home and they know that if they play with electricity they will die. With the cars that we see around is about Physics that is engineering this will boost their interest at the end I want to become an engineer so I have to take what am doing serious. They also know that the study of weather is all about Physics that is meteorologist and astronomers, I talk about the solar system about the planets and heavenly bodies they were so happy, and for that matter some of them want to become astronomers, they want to see how the planets are arranged and how the satellites move around the planets. They were so happy, it opened their minds a lot so this is what is happening in the sky, we have the force of gravity in the sky that holds the planets, so they were very happy.''

Comparing Maurice's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for Non-DARA teachers. Maurice informed his students' about the usefulness of Physics in our daily lives, career prospects and explained what would boost their interest which was in agreement with what his students responded on questions 9, 23, 25 and 33 but was in disagreement with questions 1, 35, 36 and 37 on the students' questionnaire.

> ***Teacher 4 (Elis):*** *''It is a lot, one is communication, is as a result of Physics, the transportation system is on the idea of Physics and most of the times Physics as helped produce a machine like computer which makes works easier.''*

Comparing Elis's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for Non-DARA teachers.

> ***Teacher 5 (Bismaro):*** *''The importance of Physics in fact it helps the nation to grow well and also it helps us to develop our thinking and also help us to solve problems. Medical lab technologist falls involves Physics so it helps to solve problems. If someone is suffering from a sickness and goes to the hospital, without Physics I don't think the doctor can do whatever he wants to do and also it helps the nation to grow.''*

Comparing Bismaro's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for Non-DARA teachers. Bismaro mentioned that Physics helps the nation to grow, helps us to develop our thinking, helps us to solve problems and also informed his students about careers in Physics which was in agreement with what his students responded on questions 4, 6, 20, 21, 23 and 33 but was in disagreement with questions 35, 36 and 37 on the students' questionnaire.

> ***Teacher 6 (Hannab):*** *''The study of Physics is very good, one thing now is that when you get the concept and you understand it, whenever you get in danger you can assist yourself before someone comes. We use Physics in our daily lives.''*

Comparing Hannab's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for Non-DARA teachers. Hannab informed her students' about the uses of Physics in our daily lives which was in disagreement with question 1 on the students' questionnaire.

> ***Teacher 7 (Aaro):*** *''Physics is a very nice course even if you look at those great scientist, Einstein and the rest. Those great scientist they all studied Physics. If*

you study Physics but it all depends on the aspect of Physics you are studying for example if you study astronomy it gives you about an idea on how the solar system is, about the planets and also the satellites we have in space and if you study the mechanical part it also informs you about how machines are composed and how they are made.''

Comparing Aaro's response to that of his students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for Non-DARA teachers.

Teacher 8 (Chant): *''It helps us to solve basic calculations.''*

Comparing Chant's response to that of her students' response and with the research question seven indicates that both were in agreement on the perceptions on the relevance of studying Physics with regards to the interview question ten for Non-DARA teachers.

5.3 Major Findings of the Teachers' Interview

According to the teachers:

- Hands-on activities are important factor for learning and liking Physics (DARA teachers have better equipment for practical)
- DARA has improved student performance in Physics.
- Increased uptake of science at the SHS.
- Lots of focus on teachers sharing career prospects linked to developments in astronomy. A lot of motivation for students to study Physics.
- Physics explains how the world works so is relevant.
- Previous perceptions that studying Physics only leads to a teaching career.
- Non-DARA teachers have less knowledge of careers (only medicine, engineering and teaching).
- Teachers that engaged with DARA did it for self-development, to improve their teaching and for the benefit of their students.

The results from the teachers reveal that there was no significant difference between DARA teachers and Non-DARA teachers on attitudes towards the teaching and learning of Physics, no significant difference on the perceptions on the relevance of studying

Physics and lastly DARA teachers were more knowledgeable in career aspirations/knowledge of career routes in Physics than Non-DARA teachers based on the extracts from the interview for the teachers. Hence, there was significant difference between DARA teachers and Non-DARA teachers on knowledge of career aspirations/knowledge of career routes in Physics.

Chapter 6 : Discussion of Findings

This chapter brings together the major findings from the previous chapters. It attempts to answer the research questions by mapping the students' questions on the questionnaires and teachers' interview questions to the research questions. The answers to the research questions were compared with literature. The study tries to review, compare and contrast the ideas of the various authors concerning the research questions.

The findings offer various new insights for Physics Education. Students' attitudes towards the learning of Physics, reasons to choose to study Physics, relevance of Physics, career aspirations in Physics and awareness of the GRAO in Ghana. The teachers attitudes towards the teaching of Physics, relevance of Physics and knowledge of career routes in Physics. This helps refine theoretical and other perspectives that seek to identify and collate factors associated with students' engagement with Physics in Ghana. The results affirm that fostering students' engagement with Physics in Ghana may be plausible approaches to help increase the number of students who study Physics.

6.1 Discussion of the Research Questions Relating to the Students

6.1.1 RQ1. What is the difference between DARA and Non-DARA students on attitudes towards learning Physics?

This research question focuses on attitudes of students towards the learning of Physics. Questions 1-11 on the students' questionnaire answer this question. To answer RQ1, I used the findings of the student's questionnaire with the theme ''Attitudes towards Physics''. This theme was used to explore the kinds of students' attitudes towards the learning of Physics. The idea about this theme was to get empirical evidence to base the argument that students have their own interests which are to be satisfied as they engage in Physics. When these attitudes towards learning Physics are met then they are likely to engage with Physics. This was made possible in this study through the analysis of responses by students to the list of items that has the theme ''Attitudes towards Physics''. This theme has 11 statements which was made up of nine closed and two open-ended items on attitudes of students towards the learning of Physics and students were asked to indicate the extent to which they agree or disagree with the statements.

Majority of Non-DARA students responded to the RQ more positively than the DARA students. Some DARA students also responded to the RQ more positively. Hence, there was significant difference between Non-DARA students and DARA students on attitudes towards the learning of Physics. It also reveals that Non-DARA students have positive attitudes towards the learning of Physics more than the DARA students. The attitude of students who are positive towards Physics will have a sense of liking when the learning process takes place. The findings drawn from this study appear to be consistent with Astalini et al. (2019) and Manasia (2015), which state that the exhaustive character in learning depends on the excitement of students when learning. Generally, attitudes have a solid impact on learning. The findings also showed that the students enjoy (Q25/15_4) learning Physics and were very curious about it. The student's curiosity can be motivated by the comfortable classrooms they found themselves, which is in agreement to Maharaj-Sharma and Sharma (2017) that when students learn in comfortable classroom from what the teachers said, the comfortability they get can grow their skills and increase their liking for learning Physics (Astalini et al., 2019).

The students were interested in Physics lessons and this gave the assurance that they possess abilities in Physics. This agrees with the research studies of Dewati (2015) and Astalini et al. (2019) which posited that if students want to possess these abilities, particularly in Physics or science, students must engage in something related to science or Physics. The findings indicated that the students were more interested in learning Physics and had better grades in their class exercises, quizzes, assignments and exams. This is in agreement with the findings of Hamdu and Agustina (2011) and Astalini et al. (2019), which say that students who are highly interested in learning make it possible to get high learning outcomes too, meaning that the higher the motivation, the more intensity of effort and effort is made, the higher the learning success he gets (Hamdu & Agustina, 2011; Astalini et al., 2019). This statement was in agreement with what DARA teachers said that there has been improvement in the performance of their students.

In both groups, most of the students responded that Physics is useful in their daily lives which agrees with Kaniawati et al. (2016) that Physics is a branch of scientific knowledge which can explain each natural phenomenon in daily life. It has been revealed that Physics is fundamental to the basic activities of life. Hence, students must be stimulated to pursue Physics to develop mechanisms that would further enhance the lives of mankind (Mabee et al., 2021). Students who did not see the relevance of Physics could develop a negative attitude towards it (Mabee et al., 2021).

In both groups, majority of the students had self confidence that they had ability to learn Physics, they now like to work on assignments, exercises, quizzes, exams and interested in Physics lessons. This was in agreement with what their teachers said. The students enjoyed Physics, their pleasure in learning influenced the results of learning Physics. The excitement of the students improved the outcomes of their learning (Ainley, 2011) and high achievement in Physics. Relative to Physics, Godwin and Okoronka (2015) showed that a significant relationship exists between students' attitude and their corresponding academic performance in Physics. In their research, Wilson et al (2000) concluded that students' positive attitudes towards science highly correlated with their achievement in the subject.

For question ten, which was based on question nine, some students wrote that family was of no influence at all in their decision to study Physics (Abe & Chikoko, 2020). Majority of Non-DARA students reported that their teacher was their main influence in liking Physics which was evidence of what their teachers also said that their students now have interest in Physics

The findings from the questionnaire indicated that the students enjoyed the experimental activities, which showed that the students like to think critically, find interesting new things from Physics through the inquiry they did (Astalini et al., 2019).
The teachers were able to offer activating instruction to their students which was dependent on their pedagogical content knowledge and their own level of motivation which was in agreement with what other researchers have reported (Keller, Neuman & Fischer, 2017).
In the Non-DARA schools, Our Lady of Assumption R/C Basic School (8), Entsua Mensah Preparatory/JHS (7), and Komenda College Practice Basic School (2) were outlier schools that affected the results averagely. Similarly, for the DARA schools, GAEC Basic School (5), Tiwnikli International SHS (1), Kuntunse M/A Basic School 3 (8), Jeremite

International School (13) and Unity Baptist Academy (12) were outlier schools that also affected the results averagely.

It is noteworthy to recognize the difference in the students’ attitudes towards the learning of Physics between DARA and Non-DARA students. In conclusion, there was a statistically significant difference between DARA and Non-DARA students’ attitudes towards the learning of Physics. Non-DARA students had positive attitudes towards the learning of Physics more than the DARA students. It is an indication that attitudes towards the learning of Physics concerns engagement with Physics. This conclusion is based only on responses to the students’ attitudes towards the learning of Physics. The importance of knowing students’ attitudes towards the learning of Physics has a positive effect in improving students’ engagement with Physics.

Reflecting on all these results, the fact that Non-DARA students had positive attitudes towards the learning of Physics more than the DARA students is likely because these students come from the rural area in the Central Region and are more interested in Physics likewise their teachers, they believe that Physics is the backbone of technology and would want to study it. Non-DARA students perceive Physics as personally relevant and interesting, the motivation from their teachers and making connections between Physics and their own lives, interests, and future aspirations enhanced their engagement and enthusiasm for learning Physics. On the other hand DARA students come from the Urban areas where there are many opportunities in different subjects and perhaps don’t see Physics as particularly important.

6.1.2 RQ2. What is the difference between DARA and Non-DARA students on decisions to further study Physics at the SHS, CoE and Universities?

This research question focuses on students decisions to further study Physics at the SHS, CoE and Universities. Questions 22-32 on the students’ questionnaire answer this question. To answer RQ2, I used the findings of the student’s questionnaire with the theme ‘’Reasons to study Physics’’. This theme was used to explore the student’s decisions to further study Physics at the SHS, CoE and Universities. The idea about this theme was to get empirical evidence to base the argument that students have their own choices or decisions to make which are to be satisfied as they engage in Physics. When these choices or decisions to further study Physics at the SHS, CoE and Universities are met then they are likely to engage with Physics. This theme has 11 statements which was made up of seven closed and four open-ended items. Students were asked to indicate the extent to which they agree or disagree with the statements and also provide answers in open-ended questions.

The findings indicated that majority of Non-DARA students would choose to study Physics at the SHS, CoE and Universities than the DARA students. Majority of DARA students disagreed, although Non-DARA students agreed more. Hence, there was significant difference between DARA and Non-DARA students on decisions to further study Physics at the SHS, CoE and Universities. Majority of the students reported that they would choose and have decided to study Physics. Non-DARA students responded to these questions more than the Non-DARA students. Also, the Non-DARA students gave more main reasons why they would choose to study Physics at the SHS, CoE and Universities more than the Non-DARA students. The findings from the teachers indicated that there was increased uptake of science (Physics) at the SHS and students were willing to continue at the CoE and Universities, majority for the DARA and some Non-DARA students (Archer et al., 2020). The findings are consistent with the studies which have shown that teachers have a strong influence on learner decision-making (Clotfelter, Ladd, & Vigdor, 2007; Rivkin, Hanushek, & Kain, 2005; Abe & Chikoko, 2020). The findings showed that the attitudes of students and friends was that they enjoy the teaching and learning activities, which had influence on their interest in choosing and deciding to study a specific course. These findings were in agreement with the work of Olitsky et al. (2010) and Abe and Chikoko (2020). The peers of some of the students had influence on them to decide whether to further choose to study Physics, majority of the students gave this reason (Vedder-Weiss & Fortus, 2013; Abe & Chikoko, 2020).

The findings from the teachers showed that they have motivated their students to choose Science/Physics at the SHS, CoE and Universities; therefore, this has impacted students to be interested in choosing to study Science/Physics at the SHS, CoE and Universities. This is in agreement with Krapp (2007).

Based on the findings, students at the SHS reported that they intend to study Physics at university as highlighted by Archer et al. (2020). Only a small percentage of Non-DARA students reported that they chose to study Physics either because of it being compulsory or because of lack of choice. Choosing to study Physics because one enjoys or likes it is a kind of intrinsic motivation. Intrinsic motivation is ʻʻwhen a person does or engages in an activity because of the satisfaction derived from that activity and not for the reasons of being compelled by other forces.ʼʼ (Ryan and Deci, 2008; Ogunde et al., 2017) such as taking a subject because it is compulsory or because of lack of choice. Hence, it can be suggested that intrinsic motivation was one of the factors that led some of the students to choose to study Physics at the SHS, CoE and universities. The findings of this study; however, verifies that of Gałaj (2012) study that reported that getting good grades, an extrinsic motivation factor, was the main reason why students chose to study Physics. The study also found that one of the reasons that majority of Non-DARA students chose to study Physics was because they are good at it. This is similar to choosing Physics because they do well in it and possibly have good learning results. A student can have good performance on a subject if he or she is interested in it since intrinsic motivation has been linked to academic success (Lemos & Verı´ssimo, 2014).

Students who are interested in Physics subjects and who find science subjects to be enjoyable usually tend to have a greater level of obligation necessary to pursue such subjects (Osborne et al., 2003). Such students are more likely to have good learning results, and are more likely to report that they are good at the subject. The above statement was in agreement with that of what the teachers reported.
Pursuing Physics because of good learning results is an extrinsic kind of motivation (Ogunde et al., 2017). Extrinsic motivation is that kind of motivation that is driven externally by an individual so as to attain some external outcome (Ryan and Deci, 2000). The percentages of students studying Physics because they had no choice were higher for DARA compared to Non-DARA.

In the Non-DARA set of schools, Our Lady of Assumption R/C Basic School (8), Entsua Mensah Preparatory/JHS (7), Komenda College Practice Basic School (2) and St. Michael & All Angels Anglican JHS were outlier schools that affected the results averagely. Similarly, for the DARA schools, GAEC Basic School (5), Tiwnikli International SHS (1), Kuntunse M/A Basic School 2 (7), Katapor D/M Basic School (10) and Gbawe Islamic Basic School (11) were outlier schools that also affected the results averagely.

It is important to recognize the difference in the decisions to further study Physics at the SHS, CoE and Universities between DARA and Non-DARA students. In conclusion, there was a statistically significant difference between DARA and Non-DARA with their decisions to further study Physics at the SHS, CoE and Universities. Non-DARA students gave more major reasons why they would choose to study Physics at the SHS, CoE and Universities more than the Non-DARA students. This is an indication that decisions to further study Physics at the SHS, CoE and Universities concerns engagement with Physics. This conclusion is based only on responses to the students' decisions to further study Physics at the SHS, CoE and Universities.

Non-DARA students gave more major reasons why they would choose to study Physics at the SHS, CoE and Universities more than the Non-DARA students because these students seem to have more passion, joy and excitement study Physics. Most of the students choose to further study physics as it opens up pathways to various career opportunities in various scientific fields. Furthermore, they further study Physics because of the inspirational teachers and role models they look up to that inspires them to study Physics. The students proximity to the higher education institutions of Komenda CoE and UCC likely makes them pursue further studies in Physics.

6.1.3 RQ3. What is the difference between DARA and Non-DARA students on perceptions on the relevance of studying Physics?

The essence of the above research question was to determine students' perceptions on the relevance of studying Physics. Questions 12-21 on the students' questionnaire answer this question. To answer RQ3, I used the findings of the student's questionnaire with the theme ''Relevance of Physics''. When these perceptions on the relevance of studying Physics are met then they are likely to engage with Physics. This was made possible in this study through the analysis of responses by students to the list of items that has the theme ''Relevance of Physics''. This theme has ten statements which was made up of six closed and four open-ended items were asked to indicate the extent to which they agree or disagree with the statements and also provide answers to the open-ended questions.

Majority of Non-DARA students agreed and gave reasons why it is important to study Physics at the SHS, CoE and Universities more positively than the DARA students. There was high relevance in studying Physics at the SHS, CoE and Universities among the Non-DARA students.

The interview results showed that the teachers informed their students about the relevance of Physics and careers in Physics. The teachers said that their students had perception that studying Physics only leads to a teaching career. This was in agreement with what the students also responded to on what their teachers did to help them know the relevance of Physics.

It was revealed by both teachers and their students that Physics is fundamental to the basic activities of life. Hence, teachers encouraged their students to pursue the subject to develop mechanisms that would further enhance the lives of mankind (Mabee et al., 2021). For the students not to perceive the relevance of Physics could develop a negative attitude towards it (Mabee et al., 2021). There was significant difference between DARA and Non-DARA students on the perceptions on the relevance of Physics.

In addition, the teachers used hands on activities (teaching method) which appeared to be the characteristic of activities that had the most effect on the students' perceptions: activities with active participation and input from students were reported most positively by the teachers. These findings are consistent with the literature (Assor et al., 2002; Orion et al., 1997; Reeve & Jang 2006).

DARA students in general did not have a good perception of the importance of Physics as a career. The evidence is that comparing the findings to those published by Flegg et al. (2012). The DARA students fell short in their perceptions on the relevance of Physics (Zavala & Dominguez (2016). Non-DARA students had a better perception on the relevance of Physics more than the DARA students and the DARA teachers said they have informed their students about the relevance of Physics. This was in agreement with the findings highlighted by Zavala and Dominguez (2016). I was of the belief that the DARA students would have better perceptions on the relevance of Physics than Non-

DARA students had knowledge of the relevance of Physics after taking courses in the DARA programme .

Furthermore, the DARA teachers reported that there was improvement in their students' performance. The improvement in the students and the improvement in their perception of the importance of Physics agrees with the findings of Zavala and Dominguez (2016).

In the Non-DARA schools, Our Lady of Assumption R/C Basic School (8) and St. Michael & All Angels Anglican JHS were outlier schools that affected the results averagely. Similarly, for the DARA schools, Kuntunse M/A Basic School 2 (7) and Kuntunse M/A Basic School 3 (8) were outlier schools that also affected the results averagely.

It is important to recognize the difference in the perceptions on the relevance of studying Physics between DARA and Non-DARA students. In conclusion, there was a statistically significant difference between DARA and Non-DARA with their perceptions on the relevance of studying Physics. Non-DARA students had better perceptions on the relevance of studying Physics more than the DARA students. This is an indication that perceptions on the relevance of studying Physics concerns engagement with Physics. This conclusion is based only on responses to the students' perceptions on the relevance of studying Physics.

Non-DARA students had better perceptions on the relevance of studying Physics more than the DARA students because they believe that Physics is the backbone of technology and when you study it there are so many career prospects in it. The enthusiasm and passion demonstrated by their teachers and the influence of inspiring role models in the field had shaped their perception of the relevance of studying physics. These students perceive the relevance of Physics because they have been taught by their teachers that Physics provides fundamental laws that govern the universe .

6.1.3.1 RQ4. What is the difference between DARA and Non-DARA students on career aspirations in Physics?

This research question touched on students on career aspirations in Physics. Questions 33-38 on the students' questionnaire answer this question. To answer RQ4, I used the findings of the student's questionnaire with the theme ''Career aspirations in Physics''. When these career aspirations in Physics are met then they are likely to engage with Physics. This theme has six statements which was made up of two closed and four open-ended items were asked to indicate the extent to which they agree or disagree with the statements.

Most of Non-DARA students agreed and gave reasons why they had career aspirations in Physics more positively than the DARA students. There was high career aspirations by the Non-DARA students. Majority of the Non-DARA students responded that their teachers have inspired them about careers in Physics. This agrees with what their teachers recounted that they had inspired their students about careers in Physics. The findings are in consistent with the studies which have shown that teachers have a strong influence on learner decision-making (Clotfelter, Ladd, & Vigdor, 2007; Rivkin, Hanushek, & Kain, 2005; Abe & Chikoko, 2020).

The findings of this study suggest that students had varying career aspirations and that the majority do choose to study Physics because they enjoy it and are interested in it. The findings also suggest that they are in need of help with career planning. This affirms the findings by Ogunde et al. (2017) in their research but in Chemistry.

The majority of Non-DARA students are planning a career that uses Physics. It therefore seems that most Non-DARA students have the intention of pursuing a career in which they will be able to apply Physics knowledge and skills that they acquire during their studies. Similar findings were reported by Pryor et al. (2011), who found that tertiary level students pursue their courses mainly due to career prospects. This agrees with what the teachers did in sharing career prospects to their students.

There were, however, a few students who do not have the intention of pursuing a career that uses Physics. This finding is not surprising as an earlier study by Australian Council of Deans of Science (ACDS) (2001) found that about 75% of science graduates are employed in science positions in comparison to between 25 and 30% who seemed to be in employment in non-science related careers. In this study, one reason why not all students have the aspiration of pursuing a Physics related career is because Physics students, just like other science students, have flexible rather than fixed career paths (ACDS, 2001). According to the Office of Chief Scientist (2016) in Australia, 26% of medical sciences graduates get into medical services, 19% work in hospitals but not directly providing healthcare services, whereas 13% get into tertiary education.

A higher percentage of Non-DARA students listed careers in the medical, engineering and health sciences. The findings suggest that career aspirations of the students may be influenced by teachers which agrees with what the teachers said.

The findings of this study suggest that Non-DARA students choose to study Physics because of the range of jobs available more than the Non-DARA students which is consistent with the findings of Ogunde et al. (2017) but in the Chemistry.

The study also found that a smaller percentage of DARA students chose to study Physics as a route to a specific career compared to choosing Physics for reasons of general career prospects or for the range of jobs available. These findings suggest that, whereas students may have their preferred careers, they are likely to be open to the fact that there are many career options that Physics could lead to. A large percentage of the Non-DARA students felt that job satisfaction is more important than a good salary. This attests to the findings by Ogunde et al. (2017) but in the Chemistry. Job satisfaction is the degree of a person's wellbeing that influences whether or not a person will remain in his or her job and the kind of commitment that he or she will direct toward the given job (Clark, 1996; Ogunde et al., 2017). The majority of Non-DARA students do choose to study Physics because they are interested in it and because they enjoy it.

One of the significant roles of Physics teachers is to offer career mentoring to his /her students (Buntrock, 2007). Embedding career planning in the Physics/Science course may contribute toward student satisfaction. Student satisfaction has been identified as one of the factors that affect student retention in higher education institutions (Jensen, 2011; Ogunde et al., 2017).

The findings revealed by both teachers and students showed that the encouragement and motivation received from role models such as teachers and parents was a significant contributory factor to students desire to pursue Physics careers (Wrigley-Asante et al., 2022).

Indeed, self-efficacy and external motivation were significant factors contributing to the students desire in pursuing science-related (Physics) careers in line with some of the theoretical arguments (Pajares, 2005; Buday et al., 2012).

Majority of students acknowledged the significant role of their teachers in their career decision-making and also some students felt that their families were very influential in their decision to pursue a career in Physics which verifies the research done by (Abe and Chikoko, 2020). Mzobe (2014) agrees with Young and Collin (2004) that there is an interpersonal level of influence on career decisions. This level depicts the interface of self in the decision-making process of the individual student. A study carried out by Vertsberger and Gati (2016) discovered that adolescents face career decision challenges and therefore need to seek help. This has a significantly important implication with regards to career counselling sections designed to assist students and intensifies the value of offering support for students in their career decision-making process.

The findings indicated that majority of the students recognize the variety of careers the Physics field offers or ways to apply Physics in the real world. In addition, the findings showed that Physics teachers have significant power to educate their students regarding the lack of diversity within the discipline. The teachers were the first line of contact in their responsibility to inform their students about the wide variety of career options within Physics (Parisi et al., 2023).

In the Non-DARA schools, Our Lady of Assumption R/C Basic School (8), Entsua Mensah Preparatory/JHS (7), Komenda College Practice Basic School (2) and St. Michael & All Angels Anglican JHS were outlier schools that affected the results averagely. Similarly, for the DARA schools, GAEC Basic School (5), Tiwnikli International SHS (1), Kuntunse

M/A Basic School 2 (7), Katapor D/M Basic School (10) and Gbawe Islamic Basic School (11) were outlier schools that also affected the results averagely.

Overall, the findings indicated that majority of Non-DARA students responded positively to the statement more than the DARA students. Hence, majority of the Non –DARA students had career aspirations in Physics more than the DARA students. There was significant difference between DARA and Non-DARA students on career aspirations in Physics.

In the Non-DARA schools, Our Lady of Assumption R/C Basic School (8), Komenda College Practice Basic School (2) and Aldersgate Methodist Basic School (6) were outlier schools that affected the results averagely. Similarly, for the DARA schools, GAEC Basic School (1), Jeremite International School (13) and Katapor D/M Basic School (10) were outlier schools that also affected the results averagely.

In conclusion, there was a statistically significant difference between DARA and Non-DARA with their career aspirations in Physics. Non-DARA students had better career aspirations in Physics more than the DARA students. This conclusion is based only on responses to the students' career aspirations in Physics. Non-DARA students had better career aspirations in Physics more than the DARA students because of the guidance, information they have received from their teachers. Their teachers have taught them various career opportunities in Physics. I was expecting the DARA students to have more knowledge of career routes in Physics because their teachers were involved in the DARA project and had more knowledge of careers that uses Physics but that was not the case. Many of these schools invite external speakers and others from the Physics community, such as physicists, engineers, and researchers, to share their experiences and insights which I think had exposed the students to the diverse career opportunities within the field. We were able to provide first-hand knowledge about our work, research, and the path we took to enter our respective careers.

RQ5. What is the difference between DARA and Non-DARA students on awareness of radio astronomy?

The importance of this and the last research questions for the students in this study was to explore students on awareness of radio astronomy. Questions 39-44 on the students' questionnaire answer this question. To answer RQ5, I used the findings of the student's questionnaire with the theme ''Awareness of the GRAO/DARA project in Ghana''. When these awareness of the GRAO/DARA project in Ghana are met then they may be likely to engage with Physics. This theme has six statements which was made up of four closed and two open-ended items. Students were asked to indicate the extent to which they agree or disagree with the statements and also provide answers to the open-ended questions. The theme assesses students' ''Awareness of the GRAO/DARA project in Ghana.''

From the findings, it showed that DARA students have been taught the topic ''telescopes'' in class and were able to give the meaning of the abbreviation GRAO more than the Non-DARA students. This was in agreement with what their teachers also pronounced. The teachers participated in the DARA programme and had knowledge on telescopes and GRAO. The DARA teachers reported that they use the knowledge gained from the DARA programme to teach their students for example the topics on unit 1: The Solar System of the JHS three syllabus and section 4, unit 1: Thin lenses and optical instruments of the SHS two syllabus. Hence, they were able to teach their students on the topic telescopes which was in their syllabus and what GRAO stands for.

Also, majority of the DARA students were much more aware of the DARA project in Ghana, knew where the GRAO telescope was located and had gone on an excursion to the GRAO telescope more than the Non-DARA students. This was also because their teachers were involved in the DARA programme and was in agreement with what their teachers said.

The DARA students' knowledge and experience of the GRAO telescope affected their interest to enjoy Physics positively (question 44). This agreed with what their teachers also said that the hands-on activities were an important factor for their students to like Physics. DARA students had better equipment for experiments. Conclusions drawn from the study of Okwei et al. (2022) appear to be consistent with the findings on the awareness of radio astronomy.

In the Non-DARA schools, Entsua Mensah Preparatory/JHS was an outlier school that affected the results averagely. Similarly, for the DARA schools, Tiwnikli International SHS (1), Kinbu Senior High Technical School (3) and Kwabenya Community SHS (4) were outlier schools that also affected the results averagely.

In conclusion, from the findings, it showed that majority of DARA students were more aware of radio astronomy than the Non-DARA students. Non-DARA students had less awareness. Hence, there was significant difference between DARA and Non-DARA students on the awareness of radio astronomy. DARA students were more aware of radio astronomy than the Non-DARA students because they had gone on excursions to the GRAO, their teachers have informed them about GRAO. During the launch of the GRAO it was publicise to the nation, much publicity was done in the areas the students were located (the capital city). In addition, during the astronomy clubs meeting's that the students have joined a lot of information was provided to them. At Katapor D/M Basic school the teacher and their students constructed a prototype of the GRAO telescope.

6.2 Discussion of the Research Questions Relating to the Teachers Interview Questions Based on the Findings

6.2.1.1 RQ6. What is the difference between DARA and Non-DARA teachers on attitudes towards teaching Physics?

This research question focuses on attitudes of teachers towards the teaching of Physics. Questions 1, 2, 3, 5, 6, 7, 8 and 10 on the DARA teachers interview protocol answers this question. Also, Questions 1, 2, 3, 4, 6, 7, 8 and 10 on the Non-DARA teachers interview protocol answers this question. To answer RQ6, I used the findings of the teacher's interview questions which were mapped to the answer this RQ. When these attitudes towards teaching Physics are met then they are likely to engage their students with

Physics. These interview questions were made up of eight questions for both DARA and Non-DARA teachers.

An important part of educational research is the teachers' attitudes regarding the teaching and learning of science has been (Crawford 2000; DiBiase & McDonald, 2015; King et al., 2001; Souza et al., 1997). From the findings of this study, it indicates that the teacher's motivation determines students' interest through the instruction they have received (hands-on activities, experiments and practical). It is my belief that that any student who have interest in Physics will at the same time be able to enjoy it and see its importance.

The findings from the study showed that both DARA and Non-DARA teachers used hands-on activities. DARA has improved student performance in Physics and there have been an increase uptake of science at the SHS. Hands-on activities are important factor for learning and liking Physics. The DARA teachers have better equipment for practical/experiments. This is because most of the resources/equipment/apparatuses were given to the teachers during the teacher training workshops and the DARA programme . Okwei et al. (2022) in their findings highlighted a number of hands-on activities/practical, students achievements increase uptake of science at the SHS which are in agreement with the findings of this study. Hence, the conclusions drawn from the study of Okwei et al. (2022) appear to be consistent with the findings on the teachers' attitudes towards the teaching of Physics.

The findings from the research indicated that students were motivated by their teachers to be interested in Physics this was in agreement with the findings of Keller et al. (2017) in which they found that teacher motivation mainly influences students' interest. The teachers indicated that hands-on activities are important factor for learning and liking Physics and also DARA has improved student performance in Physics. These findings were in agreement with the study of Juuti and Lavonen (2016) that allude to the fact that more emphasis should be placed on developing teacher-led demonstration and also achieving better grades seems to be the main solution.

In a study by Lee (2018), he found out that the school teacher should conduct practical work with students frequently to increase their motivation and understanding towards learning Physics. This is consistent with the findings of this study that the teachers were conduct practical and use hands-on activities in their lessons to stimulate the interest of their students which at the end made their students to like Physics. His study revealed that practical work can serve as a useful platform to develop positive effect on students' motivation and understanding towards learning Physics. Practical work helps students in gaining more interest, new experience, excitement, had a better understanding in Physics and able to collaborate with friends, motivated to score ''A'' in Physics, gain more motivation. Conclusions drawn from his studies confirm that of this study. Teachers are the most important factor that impacts students' attitudes towards Physics. The essential role that the teacher plays may positively influence students terms of their perceptions of Physics and Physics careers (Barker, 2000).

According to the teachers, hands-on activities are important factor for learning and liking Physics, this was in conformity with the results of interviews conducted by Astalini et al. (2019) which showed that the students liked the experimental activities.

Also a research by Beem (2020) on the effect of Practical Education Network (PEN)'s approach of training STEM teachers to employ hands-on activities using low-cost, locally-available resources was studied in terms of student learning outcomes, attitudes towards learning science, and interest in STEM majors/careers indicated that hands on activities had greater increase in students engagement, and a significant shift in interest towards STEM majors and careers. Beem's findings were in agreement with what the findings of what the teachers reported in answering RQ6.

In conclusion, the findings from the teachers' interview showed that there was no difference between DARA teachers and Non-DARA teachers on attitudes towards the teaching of Physics based on the extracts from the interview for the teachers. There was no difference between DARA teachers and Non-DARA teachers on attitudes towards the teaching of Physics because all of these teachers had positive attitude towards the teaching of Physics. The teachers possess strong passion, and enthusiasm for Physics. Both teachers had interested and so were their students especially Non-DARA students. The teachers were very much aware of Physics and the importance of doing Physics. The teachers had a strong educational background in Physics, such as undergraduate and postgraduate degrees in the subject, had deeper understanding and knowledge of the subject matter. This has contributed to their confidence and positive attitudes towards teaching physics.

RQ7. What is the difference between DARA and Non-DARA teachers on perceptions on the relevance of studying Physics?

The essence of the above research question was to determine teachers' perceptions on the relevance of studying Physics. This research question focuses on teachers' perceptions on the relevance of studying Physics. Questions 4 and 6 on the DARA teachers interview protocol answers this question. Also, Questions 5 and 7 on the Non-DARA teachers interview protocol answers this question. These interview questions were made up of two questions for both DARA and Non-DARA teachers to find answers to RQ7 on teachers' perceptions on the relevance of studying Physics.

The findings from the study showed that both DARA and Non-DARA teachers reported that it is very important to study Physics because Physics explains how the world works so it is relevant. Among some of the responses was that Physics is essential in the syllabus and that some of the topics they teach are relevant to their daily lives, they are able to apply the knowledge in their daily lives. These findings were in agreement with Srisatjaluk et al., (2018). The findings of this research with regards to RQ7 by the teachers showed that the applications of Physics are wide-ranging in different academic disciplines and careers.

Okwei et al. (2022) in their findings highlighted a number of importance of Physics/Astronomy, which are in agreement with the findings of this study. Hence, the conclusions drawn from the study of Okwei et al. (2022) appear to be consistent with the findings on the teachers' perceptions on the relevance of studying Physics.

In conclusion, the findings from the teachers' interview showed that there was no significant difference between DARA teachers and Non-DARA teachers on the perceptions of the relevance of studying Physics based on the extracts from the interview for the teachers.

RQ8. What is the difference between DARA and Non-DARA teachers' knowledge of career routes in Physics?

This research question focuses on teachers' knowledge of career routes in Physics. Questions 9 on the DARA and Non-DARA teacher's interview protocol answers this question. To answer RQ8, I used the findings of the teacher's interview questions which were mapped to the answer this RQ. This question was used to explore the teachers' knowledge of career routes in Physics. These interview questions was made up of only one question for both DARA and Non-DARA teachers to find answers to RQ8 on teachers' knowledge of career routes in Physics.

The findings from the study showed that the DARA teachers were more knowledgeable in career aspirations/knowledge of career routes in Physics than Non-DARA teachers based on in the sense that with the DARA teachers they had lots of focus on in sharing career prospects linked to developments in astronomy with their students. Some of the teachers had previous perceptions that studying Physics only leads to a teaching career. Non-DARA teachers have less knowledge of careers (only medicine, engineering and teaching) while the DARA teachers gave a wide range career opportunities in Physics.

There wasn't any relevant literature regarding teacher's knowledge of careers in Physics.

In conclusion, the findings from the teachers' interview showed that there was significant difference between DARA teachers and Non-DARA teachers. DARA teachers were more knowledgeable in career aspirations/knowledge of career routes in Physics than Non-DARA teachers based on the extracts from the interview for the teachers. In the private schools teachers teach differently by providing more extra tuition and activities to the students (see Table 3.4 and 3.5). DARA teachers were more knowledgeable in career aspirations/knowledge of career routes in Physics than Non-DARA teachers because during the DARA program and workshops they were informed about the various careers that uses Physics. Ongoing professional development opportunities by the DARA teachers played a crucial role in expanding their knowledge of career routes in Physics. Workshops, conferences, seminars, and collaboration with professionals from the field also exposed them to a wide range of careers and provide insights into the skills and pathways needed to pursue them. DARA teachers were well-informed about the diverse career options available to students in the field of Physics.

6.3 Summary of Findings

This study was carried out to specifically understand the impact of large scale radio astronomy projects on students' engagement with Physics in Ghana. Five variables, namely: attitudes towards the teaching and learning of Physics, relevance of Physics, reasons to choose to study Physics, career aspirations in Physics, and awareness of the GRAO telescope/DARA project in Ghana were used. The study was done at various schools in Ghana. The results of the data analysis have provided a number of findings with respect to the impact of large-scale radio astronomy projects on student's engagement with Physics in Ghana.

This study revealed that there was a statistically significant difference between DARA and Non-DARA students' attitudes towards the learning of Physics. Non-DARA students had positive attitudes towards the learning of Physics more than the DARA students. This conclusion is based only on responses to the students' attitudes towards the learning of Physics. The importance of knowing students' attitudes towards the learning of Physics has a positive effect in improving students' engagement with Physics.

There was a statistically significant difference between DARA and Non-DARA with their decisions to further study Physics at the SHS, CoE and Universities. Non-DARA students gave more major reasons why they would choose to study Physics at the SHS, CoE and Universities more than the Non-DARA students. This is an indication that decisions to further study Physics at the SHS, CoE and Universities also relates to engagement with Physics. This conclusion is based only on responses to the students' decisions to further study Physics at the SHS, CoE and Universities.

This study showed that there was a statistically significant difference between DARA and Non-DARA with their perceptions on the relevance of studying Physics. Non-DARA students had better perceptions on the relevance of studying Physics more than the Non-DARA students. This conclusion is based only on responses to the students' perceptions on the relevance of studying Physics.

This study also revealed that there was a statistically significant difference between DARA and Non-DARA with their career aspirations in Physics. Non-DARA students had better career aspirations and awareness in careers related to Physics more than DARA students. This conclusion is based only on responses to the students' career aspirations in Physics.

From the findings, it showed that majority of DARA students were more aware of radio astronomy than the Non-DARA students. Hence, there was significant difference between DARA and Non-DARA students on the awareness of radio astronomy.

The Non-DARA students who were involved in this study support the idea that the subject Physics has some, if not a lot usefulness. This notion can be as a result of a preconditioned mind of the students either by their teachers, peers, siblings or parents as to what they want them to be in future. My opinion is that, students tend to undermine and overlook the possible benefits or prospects that come with studying the subject Physics.

Furthermore, this study revealed that some DARA teachers were not inspiring their students in that majority of the students had little interest in the subject Physics. Some of the students pointed out that, their teachers did nothing to inspire them to study Physics and also there was nothing to motivate or to serve as a driving force for them to pursue the subject at higher educational levels.

In this same view, this study revealed that from the teachers' interview there was no difference between DARA teachers and Non-DARA teachers on attitudes towards the teaching and learning of Physics.

This study revealed that from the interviews conducted with the teachers, there was no difference in the perceptions on the relevance of studying Physics.

The findings of this study show that there was a more significant difference between DARA and Non-DARA student's attitudes towards learning Physics, decisions to further study Physics at the SHS, CoE/universities and perceptions on the relevance of studying

Physics but revealed that DARA students knew of more Physics careers (career aspirations in Physics) than Non-DARA students and also they were more aware of the GRAO telescope/DARA project in Ghana than Non-DARA students.

This study indicated that there was a statistically significant difference between DARA and Non-DARA students. Hence, the results show that overall there has been a low impact of large scale radio astronomy projects on student's engagement with Physics in Ghana. The impact of large scale radio astronomy projects thus has not led to high student's engagement with Physics in Ghana. However, it should also be noted that there were significant differences between the DARA and Non-DARA schools. For the DARA schools, GAEC Basic School (5) was a significant outlier and for the Non-DARA schools Our Lady of Assumption R/C Basic School (8) was a significant outlier.

The results of this study revealed that DARA students knew of more Physics careers (career aspirations in Physics) than Non-DARA students and also they were more aware of the GRAO telescope/DARA project in Ghana than Non-DARA students. DARA students were more knowledgeable in Physics careers which was due to the impact of large-scale radio astronomy projects and may have also been due to DARA teachers also having greater career awareness.

This study revealed that there was no difference between DARA teachers and Non-DARA teachers on attitudes towards the teaching of Physics and no difference in the perceptions on the relevance of studying Physics. However, DARA teachers were more knowledgeable in career aspirations/knowledge of career routes in Physics than Non-DARA teachers based on the extracts from the interview for the teachers, and this awareness was also evident from their students.

Chapter 7 : Conclusions and Recommendations

7.1 Overview

The main focus of this study was to specifically understand the impact of large scale radio astronomy projects on students' engagement with Physics in Ghana. This chapter attempts to draw conclusions and present recommendations for implementation and for the furtherance of study.

7.2 Conclusions

The main aim of this study was to specifically understand the impact of large-scale radio astronomy projects on students' engagement with Physics in Ghana.

The findings of this study show that there was more significant difference between DARA and Non-DARA student's attitudes towards learning Physics, decisions to further study Physics at the SHS, CoE/ universities and perceptions on the relevance of studying Physics but revealed that DARA students knew of more Physics careers (career aspirations in Physics) than Non-DARA students and also they were more aware of the GRAO telescope/DARA project in Ghana than Non-DARA students.

This study shows that there was a statistically significant difference between DARA and Non-DARA students. Hence, the results show that there has been a low impact of large-scale radio astronomy projects on student's engagement with Physics in Ghana. The impact of large-scale radio astronomy projects thus has not led to high student's engagement with Physics in Ghana.

The results of this study revealed that DARA students knew of more Physics careers (career aspirations in Physics) than Non-DARA students and also they were more aware of the GRAO telescope/DARA project in Ghana than Non-DARA students. DARA students were more knowledgeable in Physics.

This study revealed that there was no a difference between DARA teachers and Non-DARA teachers on attitudes towards the teaching of Physics, no difference in the perceptions on the relevance of studying Physics.

DARA teachers were more knowledgeable in career aspirations/knowledge of career routes in Physics than Non-DARA teachers based on the extracts from the interview for the teachers.

7.3 Recommendations

Based on the findings of this study, the following recommendations are made by the researcher:

1. Physics teachers need to possess not only a detailed and subtle understanding of the subject matter, but also in-depth knowledge of how best to present it in the classroom setting, what is currently called 'pedagogic content knowledge'.
2. Physics teachers should inspire and motivate their students to be engaged with the learning of Physics. Physics teacher should be the main influence for their students to like/enjoy Physics.
3. Teachers should engage with professional development programmes such as DARA. This will broaden their knowledge of Physics, career opportunities and different teaching methods.
4. Science teachers and educators are encouraged to utilize the GRAO appropriately to foster effective learning, awareness and engagement of students with Physics.
5. Physics departments should review and revise their curricula to enable more students to be engaged with Physics by using examples that demonstrate the relevance of Physics.
6. By providing students with an environment in which they attempt to explain career prospects/aspirations in Physics, relevance of Physics and reasons to choose to study Physics, they should be afforded the opportunity to continuously challenge their understandings as they evolve.
7. Physics lessons should be made more attractive by encouraging tutors to use more innovative strategies such as simulations, stories, computer animations, and videos to support and enhance learning.
8. Finally, the findings of this study can contribute to increasing students' motivation and attitudes towards Physics learning. This research is very important, especially at the high school level because motivation and attitudes can influence learning outcomes.

The following recommendations have also been made to the respective group of people based upon the findings and conclusions drawn.

Teachers

Physics teachers should teach their students about career prospects/aspirations in Physics, relevance of Physics and reasons to choose to study Physics and at higher educational levels. Physics teachers must make sure that the subject is given human and affective face. The teacher should make the teaching of Physics relevant to everyday life situations.

Physics teachers should participate in astronomy projects (like the DARA project), workshops, seminars, teacher training, outreach activities, continuous professional development programmes and conferences to enhance student's engagement with Physics. Thus, students would be interested and their attitudes towards Physics would become positive.

Parents

Parents must accept the responsibility of encouraging their children to take up the sciences and in particular Physics. Parents may also need support to understand the relevance of Physics and potential careers that arise from studying Physics.

Policy- Makers

From the research findings it was realized that the emphasis was on student's engagement with Physics and as such should be continued. However, efforts should be made by curriculum and text book writers to be focused on student's engagement with Physics and that emphasis should be placed on arousing the students' interest in Physics. Symposia, film shows and popular media should be used to sensitize students, parents and the society at large into realizing and accepting the importance of Physics.

Researchers

This was a cross-sectional study. There would be value in tracking a group of students in a longitudinal study to see if they change their views, or if there is any longer-term impact of DARA.

In order to ascertain student's engagement with Physics it is recommended that similar research be conducted, possibly for a different category of students which should be extended to cover all the JHS, SHS, CoE and Universities in the Ghana that offer Physics and possibly be given a national dimension.

On the other hand, a similar research should be conducted using only science students in SHS, CoE, and Universities to investigate the student's engagement with Physics in Ghana. Researchers should consider interventions to better engage students with Physics and the benefits of Physics. Similarly, Organise training/workshops for teachers especially Non-DARA teachers to take back to their schools, including astronomy clubs, new teaching methods, and careers awareness .

Finally, the same research can be conducted in a wider number of African countries involved with DARA to find out student's engagement with Physics in the DARA partner African countries.

7.4 Limitation

The sampling technique was not random or from the whole population. The weakness in this study is the lack of measurement in terms of affective, behavioural and cognitive engagement, but this research will be the beginning for innumerable research on students' engagement with Physics in terms of affective, behavioural and cognitive engagement. This research does not provide a national representation in Ghana on students' engagement with Physics. More research needs to be accomplished in the Ghana and other countries that would focus on the correlation between student engagement and the various teaching and learning activities that takes place in the classroom.

Understanding student engagement in Physics is indispensable in addressing the issue of uptake of Physics in JHS, SHS, CoE and Universities in Ghana. The study was a comparative study, collecting data by means of only questionnaires and interview. Perhaps, conducting a case study using more Non-DARA schools could have given a diverse report on student engagement and also conducting a longitudinal study would have been ideal to detect the development or changes of the students' engagement with Physics over long periods.

Several researchers have extensive experience of research studies on student's attitudes towards the learning of Physics. However, there is lack of numerous research studies on students and teacher's perception of the relevance of Physics.

No literature on teachers perceptions of careers is a limitation

7.5 Suggestions for Further Research

- This study could be replicated in other African countries of DARA to ascertain the impact of large scale astronomy projects with students' engagement with Physics in a number of African countries.
- In addition, this research was conducted only in Ghana; research in other DARA partner country schools, colleges and universities should be performed, as there may be other impact of large scale astronomy projects on students' engagement with Physics in these countries.
- There should be future research that would sample a larger number of students at different educational levels and institutions (i.e. secondary and tertiary) to ascertain the gender differences within the different STEM disciplines. It is also important to undertake a longitudinal study to track students studying STEM courses, to ascertain whether these students actually end up in STEM fields. These are likely to generate more knowledge on the actual impact of science education and programme on students interested in pursuing careers in STEM.
- The same research can be conducted in a number of African countries of DARA to find out student's engagement with Physics in the DARA partner African countries. Consideration of interventions to better engage students with Physics and the benefits.
- A wider programme of training for Non-DARA teachers , with follow up to see what the impact is on students.
- Finally, using the existing dataset , take a case study approach to each school, and to individual responses where outliers are detected.

References

Abe, E. N., & Chikoko, V. (2020). Exploring the factors that influence the career decision of STEM students at a university in South Africa. *International Journal of STEM Education*, *7*(1). https://doi.org/10.1186/s40594-020-00256-x

Adeyemo, S. (2010). Teaching/learning physics in Nigerian secondary school: The curriculum transformation, issues, problems and prospects. *International Journal of Educational Research and Technology, 1*(1), 99-111.

Adesokan, C. O. (2000). *Student's attitude and gender as determinants of performance in JSS integrated science.* Unpublished B.Ed. project, University of Ado – Ekiti, Nigeria.

Adu-Agyem, J., & Osei-Poku, P. (2012). Quality education in Ghana: The way forward. *International Journal of Innovative Research and Development, 1*(9), 164- 177.

Agina-Obu, T. N. (2005). The relevance of instructional materials in teaching and learning. In Robert-Okah, I., & Uzoeshi, K. C (Eds.). *Theories and practices of teaching* (pp. 203- 233). Port Harcourt: Harey Publication.

Aheto-Tsegah, C. (2011). Education in Ghana–status and challenges. *Commonwealth Education Partnerships*, 27-29.

Ainley, M., & Ainley, J. (2011). A cultural perspective on the structure of student interest in science. *International Journal of Science Education, 33*(1), 51-71. https://doi.org/10.1080/09500693.2010.51864

Akinbobola, A.O. (2009). Enhancing students' attitude towards Nigerian senior secondary school physics through the use of cooperative, competitive and individualistic learning strategies. *Australian Journal of Teacher Education, 34*(1), 1-9.

Allen, E., & Seaman, C. A. (2007). *Likert scales and data analyses*. Quality Progress, 40, 64-65. American Physics Society. (2008). *Why study physics?* Retrieved May 25, 2019, from http://www.aps.org/programmes/education/whystudy.cfm

American Physics Society. (2008). *Why study physics?* Retrieved May 25, 2019, from http://www.aps.org/programmes/education/whystudy.cfm

Anamuah-Mensah, J., Mereku, D. K., & Ampiah, J. G. (2009). *TIMSS 2007 Ghana report: Findings from IEA's trends in international mathematics and science study at the eighth grade.* Accra: Adwinsa Publications (Gh) Ltd.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2013). 'Not girly, not sexy, not glamorous': Primary school girls' and parents' constructions of science aspirations. Pedagogy, Culture & Society, 21(1), 171–194.

Archer, L., Moote, J., Francis, B., DeWitt, J., & Yeomans, L. (2017). Stratifying science: a Bourdieusian analysis of student views and experiences of school selective practices in relation to 'Triple Science' at KS4 in England, *Research Papers in Education*, *32*:3, 296-315, DOI: 10.1080/02671522.2016.1219382

Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). ASPIRES 2: *Young people's science and career aspirations, age 10-19.* London: UCL Institute of Education.

Arrigoni-Battaia, F., Löbling, L., Man, A., Asabere, B. D., Kerzendorf, W., & Valenti, E. (2018). The first ESO astronomy research training—Ghana 2018. *The Messenger*, *173*, 51-53. https://doi.org/10.18727/0722-6691/5102

Asabere, B. D., Gaylard M.J., Horellou, C., Winkler, H., & Jarrett, T. (2015). *Radio astronomy in Africa: the case of Ghana*, South Africa Institute of Physics (SAIP) Conference Proceedings. ISBN: 978-0-620-65391-6

Aslam, F., Adefila, A., & Bagiya, Y. (2018). STEM outreach activities: an approach to teachers' professional development. *Journal of Education for Teaching, 44*(1), 58–70. https://doi.org/10.1080/02607476.2018.1422618

Assor, A., Kaplan, H., & Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviours predicting students' engagement in schoolwork. *British Journal of Educational Psychology, 72,* 261–278.

Astalini, A., Darmaji, D., Pathoni, H., Kurniawan, W., Jufrida, J., Kurniawan, D. A., & Perdan, R. (2019). Motivation and attitude of students on physics subject in the middle school in Indonesia. *International Education Studies*, *12*(9), 15. https://doi.org/10.5539/ies.v12n9p15

Astalini, A., Kurniawan, D. A., Sari, D. K., & Kurniawan, W. (2019). Description of scientific normality, attitudes of investigation and interested career on physics in senior high school. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *4*(2), 56-63.

Australian Council of Deans of Science. (2001). Why do a ScienceDegree? (ACDS Occasional Paper No. 2), http://www.acds.edu.au/wp-content/uploads/sites/6/2015/04/ACDSOccP.pdf, accessed October 25, 2020.

Ausubel, D. P. (1963). *The Psychology of Meaningful Verbal Learning*. Grune and Stratton: New York,.

Ausubel, D. (1968). *Educational Psychology: A Cognitive View.* Holt, Rinehart and Winston: New York

Aworka, R., Proven-Adzri, E., Ansah-Narh, T., Koranteng-Acquah, J., & Aggrey, E. (2021). Using Ghana's 32-m radio telescope to promote astronomy outreach. *Nature Astronomy, 5*(12), 1199–1202. https://doi.org/10.1038/s41550-021-01555-1

Axelson, R. D., & Arend F. (2010). Defining student engagement. *Change: The Magazine of Higher Learning 43*(1): 38– 43.

Baeten, M., Dochy, F., & Struyven, K. (2013). The effects of different learning environments on students' motivation for learning and their achievement. *British Journal of Educational Psychology, 83*, 484–501. doi: 10.1111/j.2044-8279.2012.0207

Bandura, A. (1977). *Social learning theory*. Prentice Hall. Englewood Cliffs, NJ, 247.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W. H. Freeman and Company.

Barkley, E. F. (2010). *Student engagement techniques: A handbook for college faculty*. San Francisco, CA: Jossey-Bass.

Baumeister, R.F. & Leary, M.R. (1995). The need to belong – desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*(3): 497–529.

Beem, H. (2020). Effect of Hands-on Science Activities on the Ghanaian Student: A Preliminary Control Study. *Global Journal of Transformative Education*, *2*(1), 18–32. https://doi.org/10.14434/gjte.v2i1.31224

Berry, S.T. (2021). The SKA approach to sustainable research. In: Beck, H.P., Charitos, P. (eds) *The Economics of Big Science. Science Policy Reports*. Springer, Cham. https://doi.org/10.1007/978-3-030-52391-6_4

Bettinger, E. (2010). To be or not to be: Major choices in budding scientists. *In American universities in a global market* (pp. 69-98). University of Chicago Press.

Birch, S. H., & Ladd, G. W. (1997). The teacher-child relationship and children's early school adjustment. *Journal of school psychology*, *35*(1), 61-79. https://doi.org/10.1016/S0022-4405(96)00029-5

Buabeng, I., & Ntow, D. F. (2010). A comparison study of students' reasons/views for choosing/not choosing physics between undergraduate female non-physics and female physics students at University of Cape Coast. *International Journal of Research in Education*, *2*(2), 44-53.

Buabeng, I., Ossei-Anto, T.A, & Ampiah, G.J. (2014). An investigation into physics teaching in senior high schools. *World Journal of Education, 4* (5), 40-50.

Bucur, M. V., Shanley, D. B., & Claffey, N. (2006). Contents of stomatological curricula in Europe. *European Journal of Dental Education, 10*(2), 61–66. https://doi.org/10.1111/j.1600-0579.2006.00384.x

Buday, S., Stake, J., & Peterson, Z. (2012). Gender and the choice of a science career: The impact of social support and possible selves. *Sex Roles*, *66*(3), 197–207.

Buntrock, E. R. (2007). Careers in chemistry, J. Chem. Educ., 84(10), 1607.

Burns, N. & Grove, S.K. (2003). *Understanding nursing research*. 3rd ed. Philadelphia: WB Saunders.

Cerini, B., Murray, I. & Reiss, M. (2003). *Student review of the science curriculum. Major findings*, London: Planet Science. Retrieved March 9, 2022, from http://archive.planet-science.com/sciteach/review/Findings.pdf

Childs, A., & McNicholl, J. (2007). Investigating the relationship between subject content knowledge and pedagogical practice through the analysis of classroom discourse. *International Journal of Science Education, 29*, 1629–1653.

Clark, E. A. (1996). Job satisfaction in Britain, *Brit. J. Ind. Relat., 32*(2), pp. 189–217.

Clotfelter, C. T., Ladd, H. F., & Vigdor, J. L. (2007). *How and why do teacher credentials matter for student achievement?* (No. w12828). Cambridge: National Bureau of Economic Research.

Cohen L., Manion L. and Morrison K., (2007), *Questionnaire*, in *Research methods in education*, London: Routledge, 6th edn, pp. 137-348.

Colleges of Education. ([CoE] 2013). *Chief Examiners' Report, FDC114P*, August.

Colleges of Education. ([CoE] 2014). *Chief Examiners' Report, FDC114P*, August.

Colleges of Education. ([CoE] 2015). *Chief Examiners' Report, FDC114PP*, August.

Connell, J. P., & Wellborn, J. G. (1991). Competence, autonomy, and relatedness: A motivational model of self-system processes. *Minnesota Symposia on Child Psychology*, *23*, 43– 77.

Cracker, D. (2006). Attitudes towards science of Students enrolled in introductory level science courses. *UW-L Journal of Undergraduate Research IX*, 1-6.

Crawford, B. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching 37*(9): 916–37.

Curriculum Research and Development Division [CRDD]. (2008). *Teaching syllabus for physics (Senior High School)*. Accra: Ghana Education Service

Darmaji, Kurniawan, D. A., Parasdila, H., Irdianti. (2018). Description of science process skills' physics education students at Jambi university in temperature and heat materials. *The Educational Review, USA, 2*(9), 485-498. https://doi.org/10.26855/er.2018.09.004

Dawson, C. (2000). Upper primary boys' and girls' interest in science have they changed since 1980? *International Journal of Science Education*, *22*(26), 557-570.

Dawson C., (2002), *Practical research methods a user guide for mastering research*, London: How to Books.

De Leeuw E.D., Hox J.J and Dillman, D.A., (2008), Cornerstone of survey research, in de Leeuw E.D., Hox J.J and Dillman D.A., (ed.), *International handbook of survey methodology*, Mahwah, USA: Laurence Erlbaum Associates Inc.

Development in Africa with Radio Astronomy. (2019, November). *DARA success story…UK-SA collaboration is developing STEM skills and improving economic opportunities through radio astronomy.* Retrieved on the 15th November, 2019 from the Development in Africa with Radio Astronomy (DARA) website: https://www.dara- project.org/news

Dewati, M. (2015). Pengaruh Model Belajar dan Tingkat Penalaran Formal Terhadap Hasil Belajar Fisika Siswa. *Formatif: Jurnal Ilmiah Pendidikan MIPA, 2*(3). https://doi.org/10.30998/formatif.v3i2.118

DeWitt, J. & Osborne, J. (2008). Engaging students with science: In their own words. *School Science Review*, *30*(331): 109–116.

DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B., & Wong, B. (2011). High aspirations but low progression: The science aspirations-careers paradox among minority ethnic students. *International Journal of Science and Mathematics Education*, *9*(2), 243– 271. doi: 10.1007/s10763-010-9245-0

DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B., & Wong, B. (2013). Young children's aspirations in science: The unequivocal, the uncertain and the unthinkable. *International Journal of Science Education*, *35*(6), 1037–1063. doi: 10.1080/09500693.2011.608197

DiBiase, W., & McDonald, J. R. (2015). Science teacher attitudes toward inquiry-based teaching and learning. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *88*(2), 29–38. https://doi.org/10.1080/00098655.2014.987717

Eccles, J. (1983). Expectancies, values, and academic behavior. In J.T Spence (Ed), *Achievement and achievement motives* (pp. 75 146). San Francisco: Freeman. *Educational Philosophy and Theory, 38*(6), 713-722. Doi: 10.1111/j.1469-

Erdemir, N. (2009). Determining students' attitude towards physics through problem-solving strategy. *Asia-Pacific Forum on Science Learning and Teaching*, *10*(2), 1–19.

Eridemir, N. & Bakirci, H. (2009). The change and the development of attitudes of science teacher candidates towards branches. *Kastamonu Education Journal*, 161-170.

Finn, J. D. (1989). Withdrawing from school. *Review of educational research*, *59*(2), 117-142. https://doi.org/10.2307/1170412

Finn, J. D., & Zimmer, K. (2012). Student engagement: What is it? Why does it matter? In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement*. (pp. 97– 132). New York, NY: Springer.

Flegg, J., Mallet, D., & Lupton, M. (2012). Students' perceptions of the relevance of mathematics in engineering. *International Journal of Mathematical Education in Science and Technology*, *43*(6), 717-732.

Fortus, D. (2013). Attending to affect. *Journal of Research in Science Teaching, 51*(7), 821– 835. https://doi.org/10.1002/tea.21155

Fraser, B. J. (2007). Classroom learning environments. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 103–124). Mahwah, NJ: Lawrence Erlbaum

Fredricks, J. A. (2011). Engagement in school and out-of-school contexts: A multidimensional view of engagement. *Theory into practice*, *50*(4), 327-335. https://doi.org/10.1080/00405841.2011.607401

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*, 59-109. https://doi.org/10.3102/00346543074001059

Fredricks, J., McColskey, W., Meli, J., Mordica, J., Montrosse, B., & Mooney, K. (2011). Measuring student engagement in upper elementary through high school: A description of 21 instruments. Issues & answers. REL 2011-No. 098. *Regional Educational Laboratory Southeast*.

Gałaj, M. (2012). Students' Motivation to Learn Chemistry – Polish Scene, paper presented during the International Conference ''*New Perspective in Science Education''* in Florence on March 2012, http://chemistrynetwork.pixel-online. Org/files/SMO_papers/PL/pdf/PL_Students%20Motivation_ENG. pdf, accessed November 23, 2019.

Gaylard, M. J et al (2011). An African VLBI Network of radio telescopes *Proc. SAIP2011* pp 473–8

George, R. (2000). Measuring change in students' attitudes toward science over time: An application of latent variable growth modelling. *Journal of Science Education and Technology*, *9*(3), 213– 225. https://doi.org/10.1023/A: 1009491500456

George, R. (2006). Measuring change in students' attitudes toward science over time: An application of latent variable growth modelling. *International Journal of Sciences Education*, *28*(6), 571-589.

Gess-Newsome, J. (2013). Pedagogical content knowledge. In J. Hattie, & E. M. Anderman (Eds.), *International guide to student achievement* (pp. 257–259). New York, NY: Routledge.

Ghana Education Service (2004). *The development of education: national report of Ghana.* Available at: http://www.ibe.unesco.org/ National_Reports/ICE_2004/ghana.pdf [Accessed February 10, 2023].

Ghana Education Service. (2019, November). *Teaching syllabus for physics (senior high school 1-3).* Retrieved on the 16th November, 2019 from the Ghana Education Service website: https://mingycomputersgh.wordpress.com/shs-ges-syllabus/

Gibbon, T. B., Rotich, E. K., Kourouma, H. Y. S., Gamatham, R. R. G., Leitch, A. W. R., Siebrits, R., Julie, R., Malan, S., Rust, W., Kapp, F., Venkatasubramani, T. L., Wallace, B., Peens- Hough, A., & Herselman, P. (2014). Fibre-to-the-telescope: MeerKAT, the South African precursor to square kilometre telescope array (SKA). *Optical Metro Networks and Short-Haul Systems VI*. https://doi.org/10.1117/12.2049434

Glossary of Education Reform. (2016). Student engagement. In *great school partnership*. http://edglossary.org/student-engagement/.

Gottfried, A., Fleming, J., & Gottfried, A. (2001). Continuity of academic intrinsic motivation from childhood through late adolescence: A longitudinal study. *Journal of Educational Psychology*, *93*(1), 3– 13. https://doi.org/10.1037// 0022-0663. 93.1.3 gov/statistics/seind12/pdf/overview.pdf.

Greenfield, T. (1997). Gender- and grade-level differences in science interest and participation. *Science Education*, *81*(3), 259– 275. https://doi.org/10.1002/(SICI)1098 237X(199706)81:3<259::AID-SCE1>3.0.CO;2-C

Groccia, J. E. (2018). What Is Student Engagement? *New Directions for Teaching and Learning*, *2018*(154), 11–20. https://doi.org/10.1002/tl.20287

Guido, R. M. (2013). Attitude and Motivation towards learning physics. *International Journal of Engineering Research & Technology*, *2*(11): 2087-2094. https://doi.org/10.1093/nar/gkn1085

Guido, R. M. D. (2018). Attitude and motivation towards learning physics. arXiv preprint arXiv:1805.02293.

Gunuc, S. (2014). The Relationships between student engagement and their academic achievement. *International Journal on New Trends in Education and Their Implications, 5*, 216-231. http://www.ijonte.org

Hamdu, G., & Agustina, L. (2011). Pengaruh motivasi belajar siswa terhadap prestasi belajar IPA disekolah dasar. *Jurnal penelitian pendidikan, 12*(1), 90-96. *Handbook of motivation at school* (pp. 197–222).New York, NY: Routledge.

Hampden-Thompson, G., & Bennett, J. (2013). Science teaching and learning activities and students' engagement in science. *International Journal of Science Education, 35*(8), 1325–1343. https://doi.org/10.1080/09500693.2011.608093

Heflin, H., & Macaluso, S. (2021). Student Initiative Empowers Engagement for Learning Online. *Online Learning*, *25*(3). https://doi.org/10.24059/olj.v25i3.2414

Hesse-Biber, S.N., & Leavy, P. (2011). The Practice of Qualitative Research. London: Sage.

Higgins, E. T., & Kruglanski, A. W. (2000). Motivational science social and personality Perspectives. USA: Taylor & Francis.

Hoare, M. G. (2018). UK aid for African radio astronomy. *Nature Astronomy, 2*(7), 505–506. https://doi.org/10.1038/s41550-018-0515-z

Ibrahim, M., & Seker, H. (2022). Examination of the attitudes of grade 7 and 8 students towards stem education in Turkey and Ghana. *LUMAT: International Journal on Math, Science and Technology Education*, *10*(1), 107-126.

Institute of Physics. (2023). *Solving skills: Powering growth through physics-related apprenticeships* (IOP Publication). Retrieved on the January 2023 from https://www.iop.org/sites/default/files/2023-02/IOP-Solving-Skills-report.pdf

Ivowi, U. M. O. (1997). *Redesigning school curricula in Nigeria*. WCCI Region 2 seminar, NERDC Conference Centre, Lagos. 2-21.

Jebson, S.R., & Hena, A.Z. (2005). Students' attitude towards science subjects in senior secondary school in Adama state, Nigeria. *International Journal of* Research *in Applied, Natural and Social Sciences, 3*(3), 117-124.

Juuti, K., & Lavonen, J. (2016). How teaching practices are connected to student intention to enrol in upper secondary school physics courses. *Research in Science & Technological Education*, *34*(2), 204–218. https://doi.org/10.1080/02635143.2015.1124848

Kaniawati, I., Samsudin, A., Hasopa, Y., Sutrisno, A. D., & Suhendi, E. (2016). The influence of using momentum and impulse computer simulation to senior high school students' concept mastery. *Journal of Physics: Conference Series*, *739*(1), 1–4. https://doi.org/ 10.1088/1742-6596/739/1/012060

Kaur, D., & Zhao, Y. (2017). Development of physics attitude scale (PAS): An instrument to measure students' attitudes toward physics. *The Asia-Pacific Education Researcher*, *26*, 291-304. https://doi.org/10.1007/s40299-017-0349-y

Kearsley, G., & Shneiderman, B. (1999). Engagement theory: A framework for technology- based teaching and learning. *Educational technology*, *38*(5), 20-23.

Keengwe, J., Onchwari, G., & Agamba, J. (2014). Promoting effective e-learning practices through the constructivist pedagogy. *Education and Information Technologies, 19*, 887–898.

Keller, M. M., Goetz, T., Becker, E., Morger, V., & Hensley, L. (2014). Feeling and showing: A new conceptualization of dispositional teacher enthusiasm and its relation to students' interest. *Learning and Instruction, 33*, 29–38. doi: 10.1016/j.learninstruc.2014.03.001

Keller, M. M., Neumann, K., & Fischer, H. E. (2016). The impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest. *Journal of Research in Science Teaching*, *54*(5), 586–614. https://doi.org/10.1002/tea.21378

Keller, M. M., Neumann, K., & Fischer, H. E. (2017). The impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest. *Journal of Research in Science Teaching, 54*(5), 586–614. https://doi.org/10.1002/tea.21378

Kellermann, K. I., Orchiston, W., & Slee, B. (2005). Gordon James Stanley and the Early Development of Radio Astronomy in Australia and the United States. *Publications of the Astronomical Society of Australia*, *22*(01), 13–23. https://doi.org/10.1071/as04008

Khan, A., Shah, A., & Mahmood Zareen, R. (2012). Scientific attitude development at secondary school level: A comparison between methods of teaching language. *Review in India*: 439-445.

King, K., L. Shumow, & S. Lietz. (2001). Science education in an urban elementary school: Case studies of teacher beliefs and classroom practices. *Science Education 85*: 89–110.

Kingir, S., Tas, Y., Gok, G.,& Vural, S. (2013). Relationships among constructivist learning environment perceptions, motivational beliefs, self-regulation and science achievement. *Research in Science and Technological Education*, *31*(3), 205–226. doi: 10.1080/02635143.2013.825594

Kleickmann, T., Richter, D., Kunter, M., Elsner, J., Besser, M., Krauss, S., & Baumert, J. (2013). Teachers' content knowledge and pedagogical content knowledge: The role of structural differences in teacher education. *Journal of Teacher Education, 64*(1), 90– 106. doi: 10.1177/0022487112460398

Klem, A. M., & Connell, J. P. (2004). Relationships matter: Linking teacher support to student engagement and achievement. *Journal of School Health, 74*(7), 262–273. https://doi.org/10.1111/j.1746-1561.2004.tb08283.x

Koohawayrojanapakorn S, Arayapisit T, Mitrirattanakul S, Srisatjaluk R, Sipiyaruk K. (2018). Perceptions of students and instructors towards relevance of physics in Mahidol Dental curriculum: A questionnaire survey. *M Dent J*; 38: 79-90.

Krapp, A. (2007). An educational-psychological conceptualisation of interest. *International Journal for Educational and Vocational Guidance, 7,* 5–21. doi: 10.1007/s10775-007- 9113-9

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education, 33*(1), 27–50. doi: 10.1080/09500693.2010.518645

Kuh, G. D. (2003). What we're learning about student engagement from NSSE. *Change*, *35*(2), 35-44

Kunter, M., & Holzberger, D. (2013). Loving teaching: Research on teachers' intrinsic orientations. In P. W. Richardson, S. A. Karabenick, & H.M. G.Watt (Eds.), *Teacher motivation: Theory and practice* (pp. 83– 99).New York, NY: Routledge.

Kunter, M., Klusmann, U., Baumert, J., Richter, D., Voss, T., & Hachfeld, A. (2013). Professional competence of teachers: Effects on instructional quality and student development. *Journal of Educational Psychology, 105*(3), 805–820. doi: 10.1037/a0032583

Kunter, M., Tsai, Y.-M., Klusmann, U., Brunner, M., Krauss, S., & Baumert, J. (2008). Students' and mathematics teachers' perceptions of teacher enthusiasm and instruction. *Learning and Instruction, 18*(5), 468–482. doi: 10.1016/j.learninstruc.2008.06.008

Leavy, P. (2017d). *Research design: Quantitative, qualitative, mixed methods, arts-based, and community-based participatory research approaches*. New York, NY: Guilford Press.

Leavy, P. (2014). Method Meets art, second edition: Arts-based research practice. New York: Guilford Publications.

Lee, M. C., & Sulaiman, F. (2018). The effectiveness of practical work on students' motivation and understanding towards learning physics. *International Journal of Humanities and Social Science Invention, 7*(8), 2319-7714.

Lemos, S. M. & Verı´ssimo, L. (2014). The relationships between intrinsic motivation, extrinsic motivation, and achievement, along elementary school, *Proced. Soc. Behav. Sci., 112*, 930–938

Mabee, M. K. A., Haruna, T. Z., & Salifu, A. (2021). Attitude of students towards the study of physics: A case of Tamale College of education, Ghana. *Journal of Education and Learning Technology*, 10–16. https://doi.org/10.38159/jelt.2021212

Maharaj-Sharma, R., Sharma, A., & Sharma, A. (2017). Using ICT-based Instructional Technologies to Teach Science: Perspectives from Teachers in Trinidad and Tobago. *Australian Journal of Teacher Education, 42*(10), 23–35. https://doi.org/10.14221/ajte.2017v42n10.2

Manasia, L. (2015). Enjoyment of learning in upper secondary education. An exploratory research. *Procedia-Social and Behavioural Sciences, 180*, 639-646. https://doi.org/10.1016/j.sbspro.2015.02.172

McBride, V., Venugopal, R., Hoosain, M., Chingozha, T., & Govender, K. (2018). The potential of astronomy for socioeconomic development in Africa. *Nature Astronomy, 2*(7), 511–514. https://doi.org/10.1038/s41550-018-0524-y

Meece, J. L. (1990). The classroom context and students' motivational goals. In M. L. Maehr & P. R. Pintrich (Eds.), *Advances in motivation and achievement: Vol. 7. Goals and self-regulatory processes* (pp. 261–285). Greenwich, CT: JAI Press

Miley, G., Ödman, C., & Russo, P. (2019). The Inspiring Universe. *Seeking Understanding*, 119–135. https://doi.org/10.1163/9789004416802_011

Miliszewska, I., & Horwood, J. (2006). Engagement theory. ACM SIGCSE Bulletin, 38(1), 158–162. https://doi.org/10.1145/1124706.1121392

Ministry of Environment, Science, Technology & Innovation. (2017, August). *Launch of Ghana Radio Astronomy Observatory.* Retrieved on 17th November, 2019 from the Ministry of Environment, Science, Technology & Innovation website: http://mesti.gov.gh/launch-ghana-radio-astronomy-observatory/

Moeed, A. (2013). Science investigation that best supports student learning: Teachers understanding of science investigation. *International Journal of Environmental* *and Science Education*, *8*(4), 537–559. https://doi.org/10.12973/ijese.2013.218a

Moos, R. H. (1980). Evaluating classroom learning environments. *Studies in Educational Evaluation*, *6*(3), 239–252. doi: 10.1016/0191-491X(80)90027-9

Murray, H. G. (2007). Low-inference teaching behaviours and college teaching effectiveness: Recent developments and controversies. In R. P. Perry, & J. C. Smart (Eds.), *The scholarship of teaching and learning in higher education* (pp. 145–200). Dordrecht: Springer.

Mzobe, N. (2014). *A qualitative exploration of the career narratives of six South African Black professionals (Doctoral dissertation).* Durban: University of KwaZulu-Natal.

Newmann, F., Wehlage, G., & Lamborn, S. (1992). The significance and sources of student engagement. In F. Newmann (Ed.), *Student engagement and achievement in American secondary schools*. (pp. 11– 39). New York: Teachers College Press.

Newbill, P. L. (2005). *Instructional strategies to improve women's attitudes towards science.* Dissertation submitted to the faculty Virginia polytechnic Institute and State University in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Curriculum and Instruction.

Nilsson, P., & van Driel, J. (2010). How will we understand what we teach? - Primary student teachers' perceptions of their development of knowledge and attitudes towards Physics. *Research in Science Education*, *41*(4), 541–560. https://doi.org/10.1007/s11165-010-9179-0

OECD. (2006). *Evolution of student interest in science and technology studies policy report*. Paris: Author.

Office of Chief Scientist, (2016), Australia's Stem Workforce: science, technology, engineering and mathematics, Australian Government, Canberra.

Ogbuehi, P. I., & Fraser, B. J. (2007). Learning environment, attitudes and conceptual development associated with innovative strategies in middle-school mathematics. *Learning Environments Research*, *10*(2), 101–114. doi: 10.1007/s10984-007-9026-z

Ogden Trust. (2019) *GCSE physics syllabus: Making physics matter.* Retrieved from the Ogden Trust website: https://www.ogdentrust.com/

Ogunde, J. C., Overton, T. L., Thompson, C. D., Mewis, R., & Boniface, S. (2017). Beyond graduation: motivations and career aspirations of undergraduate chemistry students. *Chemistry Education Research and Practice*, *18*(3), 457–471. https://doi.org/10.1039/c6rp00248j

Okwei, E. T., Forson, A., Proven-Adzri, E., Ahenkora-Duodu, K., Kalognia, J., Abotsi-Masters, S., & Andorful, F. (2022). Promoting radio astronomy in Ghana through school visits and Astronomy Clubs. *Physics Education*, *57*(5), 055033.

Olasimbo, O., & Rotimi, C.O. (2012). "Attitudes of students towards the study of physics in college of education Ikere Ekiti, Ekiti State, Nigeria." *American International Journal of Contemporary Research,* 29(12), 86-89.

Olatoye, R. A. (2002). *A casual model of school factors as determinants of science achievement in Lagos state secondary schools*. Unpublished Ph.D Thesis, University of Ibadan, Ibadan.

Olayinka, F. (2022). Astronomy education outreach in Nigeria: the AWB Nigeria success story. *African Science Stars Magazine (4),* 17-20. https://assap.co.za/wp-content/uploads/2022/10/African-Science-Stars_WIA.pdf

Olitsky, S., Flohr, L. L., Gardner, J., & Billups, M. (2010). Coherence, contradiction, and the development of school science identities. *Journal of Research in Science Teaching, 47*(10), 1209–1228.

Olowojaiye, F. B. (2000). *A comparative analysis of student's interest in and perception of teaching / learning of mathematics at senior secondary schools levels.* A paper presented at MAN conference ''EKO2000".

Olusegun, A. J., Fatima, A., & Wakeel, F. A. (2019). Development and Position of Africa in Science and Technology Today. *American International Journal of Sciences and Engineering Research, 2*(2), 49–57. https://doi.org/10.46545/aijser.v2i2.103

Orchiston, W., & Slee, B. (2017). The early development of Australian radio astronomy: the role of the CSIRO Division of Radiophysics field stations. *The emergence of astrophysics in Asia: Opening a new window on the Universe*, 497-578.

Orion, N., Hofstein, A., Tamir, P., & Giddings, G. J. (1997). Development of an instrument for assessing the learning environment of outdoor science activities. *Science Education, 81*(2), 161–171.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049– 1079. doi: 10.1080/0950069032000032199

Osborne, J. & Collins, S. (2000). *Pupils' and parents' views of the school science curriculum*, London: Kings College London.

Pajares, F. (2005). Gender differences in mathematics self-efficacy beliefs. In A. M. Gallagher & J. C. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 294–315). Boston: Cambridge University Press

Pangaro, L. (2010). The role and value of the basic sciences in medical education: the perspective of clinical education–students' progress from understanding to action. *J Int Assoc Med Sci Educ, 20*(3), 307-13.

Parahoo, K. (1997). *Accounting research: Principles, process and issues*. Basingstoke: Macmillan.

Parisi, E., Masia, G., Reynolds, C., & Richards, A. J. (2023). Investigating high school students' perception of careers and diversity issues within physics. *The Physics Teacher*, *61*(2), 140–146. https://doi.org/10.1119/5.0054759

Patall, E. A. (2013). Constructing motivation through choice, interest, and interestingness. *Journal of Educational Psychology*, *105*(2), 522-534. https://doi.org/10.1037/a0030307

Patall, E. A., Cooper, H., & Wynn, S. R. (2010). The effectiveness and relative importance of choice in the classroom. *Journal of educational psychology*, *102*(4), 896-915. https://doi.org/10.1037/a0019545

Patall, E. A., Cooper, H., & Robinson, J. C. (2008). The effects of choice on intrinsic motivation and related outcomes: A meta-analysis of research findings. *Psychological Bulletin*, *134(*2), 270– 300. https://doi.org/10.1037/0033-2909.134.2.270

Patton, M. Q. (2015). *Qualitative research and evaluation methods*. 4th ed. Thousand Oaks: Sage

Pekrun, R., & Linnenbrink-Garcia, L. (2012). Academic emotions and student engagement. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement*. (pp. 259– 282). New York, NY: Springer.

Piaget, J. (1964). Development and learning. *Journal of Research in Science Teaching, 2*: 176–180

Piaget, J. (1970). "Piaget's theory". *In Carmichael's Manual of Child Psychology*, 3rd, Edited by: Mussen, P.H. Vol. 1, New York: John Wiley. G. Cellerier, and J. Langer, with assistance of B. Inhelder, and H. Sinclair (trans)

Pike, G. R., & Kuh, G. D. (2005). First-and second-generation college students: A comparison of their engagement and intellectual development. *The Journal of Higher Education*, *76*(3), 276–300.

Pink, D. H. (2010). *Drive: the surprising truth about what motivates us*. New York: Penguin-Riverhead.

Potvin, P., & Hasni, A. (2014). Interest, motivation and attitude towards science and technology at K-12 levels: systematic review of 12 years of educational research. *Studies in Science Education, 50*(1), 85–129. doi: 10.1080/03057267.2014.881626

Pović, M., Backes, M., Baki, P., Baratoux, D., Tessema, S. B., Benkhaldoun, Z., & Yilma, A. (2018). Development in astronomy and space science in Africa. *Nature Astronomy*, *2*(7), 507-510. https://doi.org/10.1038/s41550-018-0525-x

PRAGSAC. (2018, November). *Developments and Outreach Project in Ghana*. Retrieved from the Promoting Radio Astronomy in Ghana through School visits and Astronomy clubs (PRAGSAC) website: https://www.pragsac.org

Promoting Radio Astronomy in Ghana through School visits and Astronomy Clubs. (2018, November). *Developments and outreach project in Ghana*. Retrieved from the Promoting Radio Astronomy in Ghana through School visits and Astronomy clubs (PRAGSAC) website: https://www.pragsac.org

Pryor, J. H., et al. (2011). *The American freshman: national norms fall cooperative institutional research*, http://heri.ucla.edu/PDFs/pubs/TFS/Norms/Monographs/The A mericanFreshman2011-Expanded.pdf, accessed October 10, 2019.

Qarareh, A. O. (2016). The effect of using the constructivist learning model in teaching science on the achievement and scientific thinking of 8th grade students. *International Education Studies, 9*(7), 178. https://doi.org/10.5539/ies.v9n7p178

Ratelle, C.F., & Duchesne, S. (2014). "Trajectories of Psychological Need Satisfaction from Early to Late Adolescence as a Predictor of Adjustment in School." *Contemporary Educational Psychology* 39: 388–400. doi:10.1016/j.cedpsych.2014.09.003.

Reeve, J., & Jang, H. (2006). What teachers say and do to support students' autonomy during a learning activity. *Journal of Educational Psychology, 98*(1), 209–218.

Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012) Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology, 104*, 700-712. https://doi.org/10.1037/a0027268

Rivard, L. P., & Straw, S. B. (2000). The effect of talk and writing on learning science: An exploratory study. *Science Education*, *84*(5), 566–593. https://doi.org/10.1002/1098- 237x (200009)84:5%3C566::aid-sce2%3E3.0.co;2-u

Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools, and academic achievement. *Econometrica, 73*(2), 417–458.
Roulston J.K., (2008), Open-ended questions, in Given L. M. (ed.), *The sage encyclopaedia of qualitative research methods*, Los Angeles: Sage, vol. 1 and 2, p. 582.
Ryan, M. R. & Deci, E. R. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions, *Contemp. Educ. Psychol., 25*, 54–67.
Ryan, M. R. & Deci, E. R. (2008). Facilitating optimal motivation and psychological well-being across life's domain, *Canadian Psychology, 49*(1), 14–23
Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68– 78. https://doi.org/10.1037/0003-066X.55.1.68
Salta, K., & Tzougraki, C. (2004). Attitude toward Chemistry among 11th grades students in high schools in Greece. *Science Education, 88*(4), 535-547.
Schiefele, U., & Schaffner, E. (2015). Teacher interests, mastery goals, and self-efficacy as predictors of instructional practices and student motivation. *Contemporary Educational Psychology, 42,* 159–171. doi: 10.1016/j.cedpsych.2015.06.005
Schmidt, J. A., Rosenberg, J. M., & Beymer, P. N. (2017). A person-in-context approach to student engagement in science: Examining learning activities and choice. *Journal of Research in Science Teaching, 55*(1), 19–43. https://doi.org/10.1002/tea.21409
Schultz, R. A. (2015). Revisiting constructivist teaching methods in Ontario colleges preparing for accreditation. *College Quarterly, 18*(2), n2.
Sinatra, G. M., Heddy, B. C., & Lombardi, D. (2015). The challenges of defining and measuring student engagement in science. *Educational Psychologist, 50*(1), 1–13. https://doi.org/10.1080/00461520.2014.1002924
Sjøberg, S., & Schreiner, C. (2005a). *The ROSE project: an overview and key findings*. Retrieved from http://roseproject.no/network/countries/norway/eng/nor-Sjoberg-Schreiner-overview-2023.pd
Skinner, E. A., & Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behaviour and student engagement across the school year. *Journal of Educational Psychology, 85*(4), 571–581. https://doi.org/10.1037/0022-0663.85.4.571
Sofeme, R.J., & Hena, A.Z. (2015). Students` attitude towards science subjects in senior secondary schools in Adamawa state, Nigeria: *International Journal of Research in Applied, Natural and Social Sciences, 3*(3), 117-120.
Somanah, R., & Udaya Shankar, N. (2002). Study of extended radio galaxies at 151.6 MHz using the Mauritius radio telescope. *Astrophysics and space science*, *282*, 57-67.
Sooryamoorthy, R. (2020). Science, Development and Africa. *In Science, Policy and Development in Africa: Challenges and Prospects* (pp. 1-40). Cambridge: Cambridge University Press. doi:10.1017/9781108895804.002
Souza Barros, S., & Elia, M. F. (1997). Physics teacher's attitudes: How do they affect the reality of the classroom and models for change. *Connecting research in physics education with teacher education*, 86-90
Square Kilometre Array (SKA) Project. (2019, November). *The Project*. Retrieved from the Square Kilometre Array website: https://www.ska.ac.za/about/the-project/
Srisatjaluk, R. L., Koohawayrojanapakorn, S., Arayapisit, T., Mitrirattanakul, S., & Sipiyaruk, K. (2018). Perceptions of students and instructors towards relevance

of physics in Mahidol Dental curriculum: A questionnaire survey. *Mahidol Dental Journal*, *38*(2), 79- 90.

Statistics guides by Wallstreetmojo Team https://www.wallstreetmojo.com/kruskal-wallis-test/

Statistics simplified https://www.statology.org/fishers-exact-test/

Statistics solutions https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/mann-whitney-u-test/

Statistics solutions. https://www.statisticssolutions.com/free-resources/directory-of statisticalanalyses/correlation-pearson-kendall-spearman/

Strubbe, L., Okere, B. I., Zhang, J., Chibueze, J. O., Ikape, M., Okouma, P. M., Ibik, A., White, H., Abotsi-Masters, S., Man, A., Webb, S., Asabere, B. D., Bop, C. T., Esaenwi, S., Mowla, L., Nguyen, T. D. C., Odo, F., Odoh, D., Ofodum, C. N., & Onyeuwaoma, N. (2021). The Pan-African School for emerging astronomers. *Nature Astronomy, 5*(3), 217–220. https://doi.org/10.1038/s41550-021-01301-7

Stuckey, M., Hofstein, A., Mamlok-Naaman, R., & Eilks, I. (2013). The meaning of "relevance" in science education and its implications for the science curriculum. *Studies in Science Education, 49*(1), 1–34. https://doi.org/10.1080/03057267.2013.802463

Superprof Magazine. (2019) GCSE Physics Syllabus: *All the Topics at a Glance.* Retrieved from the Superprof Magazine website: https://www.superprof.co.uk/blog/all-the-topics-considered-in-the-GCSE-Physics-syllabus/

Taylor, S. A., Hunter, G. L., Melton, H., & Goodwin, S. A. (2011). Student engagement and marketing classes. *Journal of Marketing Education, 33*, 73-92. https://doi.org/10.1177/0273475310392542
Technologies, 19, 887–898.

The West African Examination Council. ([W.A.E.C] 2006). *General Resume of Chief Examiners' Report, WASSCE, May/June.*

The West African Examination Council. ([W.A.E.C] 2012). *General Resume of Chief Examiners' Report, WASSCE, May/June.*

Thomas, G. (2017). *How to do your research project.* 2nd ed. London: SAGE.

Tikly, L., Joubert, M., Barrett, A. M., Bainton, D., Cameron, L., & Doyle, H. (2018). *Supporting secondary school STEM education for sustainable development in Africa*. Bristol Working Papers in Education.

Tillinghast, R. C., Appel, D. C., Winsor, C., & Mansouri, M. (2020). STEM outreach: A literature review and definition. In *2020 IEEE Integrated STEM Education Conference (ISEC)* (pp. 1-20). IEEE.

Torto, G. A. (2020). Investigating the type of student engagement that exists in English classrooms of public basic schools in Ghana. *Open Journal of Social Sciences*, *8*(09), 69.

Trebi-Ollennu, A., & Okraku-Yirenkyi, Y. (2014). Precollege Students RiSE to STEM Activities in Ghana [Member Activities]. *IEEE Control Systems Magazine*, *34*(4), 16-20.

Trumper, R. (2003). The need for change in elementary school teacher training: A cross-college age study of future teachers' conceptions of basic astronomy topics. *Teaching and Teacher Education, 19*(3), 309-323.

Tuan, H., Chin, C., & Shieh, S., (2005). The development of a questionnaire to measure students' motivation towards science learning, *International Journal of Science Education, 27*(6), 639–654.

Turner P. R., K. Fowler, D. Wick, M. Ramsdell, G. Gotham, E. Glasgow, & C. French, eds. (2007). *Math and science symposium. BOCES-University partnership as a model for educational outreach: K-16 STEM professional development.* Knoxville, TX.

Vedder-Weiss, D., & Fortus, D. (2013). School, teacher, peers, and parents' goals emphases and adolescents' motivation to learn science in and out of school. *Journal of Research in Science Teaching, 50*(8), 952–988. https://doi.org/10.1002/tea.21103

Vennix, J., den Brok, P., & Taconis, R. (2017). Perceptions of STEM-based outreach l earning activities in secondary education. *Learning Environments Research*, *20*(1), 21–46. https://doi.org/10.1007/s10984-016-9217-6

Vennix, J., den Brok, P., & Taconis, R. (2018). Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM? International Journal of Science Education, 40(11), 1263–1283. https://doi.org/10.1080/09500693.2018.1473659

Vertsberger, D., & Gati, I. (2016). Career decision-making difficulties and help-seeking among Israeli young adults. *Journal of Career Development, 43*(2), 145– 159.

Vygotsky, L.S. (1978). *Mind and Society: The Development of Higher Mental Processes*, Cambridge, MA: Harvard University Press.

WAEC (2014). *May/June SSSCE Results 1990-2014*. Accra: West African Examinations Council. from http://www.ghanawaec.org/ExaminerWAECMAYJUNE.aspx

Wilson, Victor L., Ackerman, Cheryl & Malave, Ceasar (2000). Cross –Time attitudes, concept formation, and achievement in college freshman Physics. *Journal of Research in Science Teaching,* 37(10), 1112-1120.

Wonglorsaichon, B., Wongwanich, S., & Wiratchai, N. (2014). The influence of students school engagement on learning achievement: A structural equation modelling analysis. *Procedia—Social and Behavioural Sciences, 116*, 1748-1755. https://doi.org/10.1016/j.sbspro.2014.01.467 http://www.sciencedirect.com

Woods, N. N., Brooks, L. R., & Norman, G. R. (2005). The value of basic science in clinical diagnosis: creating coherence among signs and symptoms. *Medical Education, 39*(1), 107–112. https://doi.org/10.1111/j.1365-2929.2004.02036.x

Wrigley-Asante, C., Godfred Ackah, C., & Kusi Frimpong, L. (2022). Career aspirations and influencing factors among male and female students studying Science Technology Engineering and Mathematics (STEM) subjects in Ghana. *Ghana Journal of Geography*, *14*(1). https://doi.org/10.4314/gjg.v14i1.5

Wu, Z. Y., Zhang, Z. Y., Jiang, X. Q., & Guo, L. (2010). Comparison of dental education and professional development between mainland China and North America. *European Journal of Dental Education*, *14*(2), 106-112. www.phy.ilstu.edu/jpteo/...

Yance, R. D., Ramli, E., & Mufit, F. (2013). Pengaruh penerapan model project based learning (PBL) terhadap hasil belajar fisika siswa kelas XI IPA SMA Negeri 1 Batipuh Kabupaten Tanah Datar. *Pillar of Physics Education*, *1*(1), 48–54. Retrieved from http://e journal.unp.ac.id/students/index.php/pfis/article/view/490/279

Young, R. A., & Collin, A. (2004). Introduction: Constructivism and social constructionism in the career field. *Journal of Vocational Behaviour, 64*(3), 373–388.

Zaitoon, A. (2007). *Constructivism theory and strategies of teaching science*. Amman: Dar al Shorook for publication and distribution
Zavala, G., & Dominguez, A. (2016). *Engineering students' perception of relevance of physics and mathematics.* Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.26664
Zavala, G., Dominguez, A., Millan, A. C., & Gonzalez, M. (2015). Students' perception of relevance of Physics and mathematics in engineering majors. In *2015 ASEE Annual Conference & Exposition* (pp. 26-1435).
Zhaoyao, M. (2002). Physics education for the 21st century: Avoiding a crisis. *Physics Education, 37*(1), 18-24.

Appendices

Appendix 1

UNIVERSITY OF LEEDS

Questionnaire for Students

This questionnaire is strictly for academic purpose and you are assured of its complete anonymity as well as all information provided would be treated with confidentiality. As such you need not write your name on the questionnaire. It is my hope that you will feel free to respond to the questions as frankly as possible. All questions are optional. I understand that by completing and returning this questionnaire I am consenting to taking part in this study. All responses are anonymous therefore withdrawal will not be possible.

Section A

General Information

Please tick in the boxes your sex and provide your age.

A. Sex: i. Male [ ] ii. Female [ ]

B. Age : (in years) ___________________

C. School ____

Section B

Please tick in the boxes the extent to which you agree or disagree with the statements about the teaching and learning of Physics in your school.

The options are:

SA= Strongly Agree A = Agree U = Undecided D = Disagree SD= strongly disagree

Attitudes Towards Physics

S/N	Items	SA	A	U	D	SD
1.	Physics is useful in our daily lives.					
2.	I like Physics better than any subject.					
3.	Physics should be made optional in our educational curriculum.					

4.	Physics increases my ability to think logically. Physics helps me to be systematic. Physics helps me to be accurate. Physics helps me to be objective.					
5.	Physics runs through many other subjects.					
6.	Physics increases my ability to solve real life problems.					
7.	I enjoy the challenges presented by Physics problems.					
8.	I would have stopped studying Physics if it had been optional.					
9.	My teacher was my main influence in liking Physics.					

10. From question 9, what else influence you?

11. What did your teacher do to make you like Physics?

Relevance of Physics

S/N	Items	SA	A	U	D	SD
12	Is it important to study Physics at the SHS?					

13. Give reasons for your answer in question 12 above?

S/N	Items	SA	A	U	D	SD
14	Is it important to study Physics at the Colleges of Education?					

15. Give reasons for your answer in question 14 above?

S/N	Items	SA	A	U	D	SD
16	Is it important to study Physics at the Universities?					

17. Give reasons for your answer in question 16 above?

18. What did your teacher do to help you know the relevance of Physics?

S/N	Items	SA	A	U	D	SD
19	Physics is relevant to the kind of work that you want to do					
20	Physics is important for the country's future wealth					
21	Physics helps me to solve problems in life					

Reasons to Choose to Study Physics

S/N	Items	SA	A	U	D	SD
22	You study Physics because you had no choice / it was compulsory					
23	You study Physics because of the range of jobs available					
24	You study Physics because you are good at it / it's your best subject					
25	You study Physics because you have interest in the subject / enjoy it					

26	Will you choose to study Physics at the SHS?					
27	Will you choose to study Physics at the Colleges of Education?					
28	Will you choose to study Physics at the Universities?					

29. Give any other reasons for choosing to study Physics.

30. State the main reasons in question 26 above.

31. State the main reasons in question 27 above.

32. State the main reasons in question 28 above.

Career Aspirations in Physics

S/N	Items	SA	A	U	D	SD
33	I'm planning a career that uses Physics					

34. Give your reasons to question 33 above.

35. What careers are you considering and why?

36. List as many careers you think uses Physics.

37. What did your teacher do to inform or inspire you about careers in Physics?

S/N	Items	SA	A	U	D	SD
38	Job satisfaction is more important to me than a good salary					

Awareness of the Ghana Radio Astronomy Observatory Telescope / Development in Africa with Radio Astronomy (DARA) project in Ghana

Please tick in the boxes the extent to which you are aware of the telescope / Development in Africa with Radio Astronomy (DARA) project in Ghana.

S/N	Items	Yes	No	Not Sure
39	Have you been taught the topic ‘‘telescopes’’ in class?			
40	Are you aware of the DARA project in Ghana?			

41. What does GRAO stands for?

S/N	Items	Yes	No	Not Sure
42	Do you know where the GRAO telescope is located?			
43	Have you gone on an excursion to the GRAO telescope?			

44. In what ways have your knowledge/experience of the GRAO telescope affected your interest in Physics?

Appendix 2

UNIVERSITY OF LEEDS

Interview Protocol for Teachers (DARA/ Non-DARA) on the Impact of the DARA Project on Students Engagement with Physics in Ghana

Time: 20-30 minutes

DARA Teachers

1. Why did you choose to get involved with the DARA training?
2. How has DARA changed the way you teach?
3. How has DARA impacted on your students towards Physics?
4. Has there been a change in the attitudes of the students you teach towards Physics? If ''Yes'' why and if ''No'' why?
5. How do you inspire your students to engage with Physics learning and to further study Physics in the Senior High Schools / Universities / Colleges of Education / Polytechnics etc?
6. What motivation do you give to your students for the learning of Physics?
7. Are your students aware of the telescope in Kuntunse (Ghana Radio Astronomy Observatory, GRAO)? How do you know? If ''Yes'' why and if ''No'' why?
8. How do you use the knowledge gain from the DARA training to help your students study Physics?
9. What are your perceptions about careers that involve Physics?
10. What are your perceptions about the relevance of studying Physics?

Non-DARA Teachers

11. Are you aware of the DARA project in Ghana? If ''Yes'' why and if ''No'' why?
12. If response to question 1 is ''Yes'' - What do you think about it? If ''No'', what awareness do you know?
13. Would you like to be part of the DARA basic training in astronomy in Ghana? If ''Yes'' why and if ''No'' why?

14. Would you like to be part of the DARA outreach team in Ghana? If ''Yes'' why and if ''No'' why?
15. Has there been a change in the attitudes of the students you teach towards Physics? If ''Yes'' why and if ''No'' why?
16. How do you inspire your students to engage with Physics learning and to further study Physics in the Senior High Schools / Universities / Colleges of Education / Polytechnics etc.?
17. What motivation do you give to your students for the learning of Physics?
18. Are your students aware of the telescope in Kuntunse (Ghana Radio Astronomy Observatory, GRAO)? If ''Yes'' why and if ''No'' why?
19. What are your perceptions about careers that involve Physics?
20. What are your perceptions about the relevance of studying Physics?