The Effects of Science Research Based Competitions on High School Students' Responses to Science

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PhD Thesis

The University of York

Department of Education

March 2012

Abstract

The purpose of this study is to understand the effects of Science Research Based Competitions (SRBCs) on high school students' responses to science. SRBCs were primarily designed to develop students' interest in science, their motivation for science learning and their science reasoning in order to provide a platform for students to show potential for carrying out research in science. But, despite their popularity, little research has so far been undertaken to evaluate the effects of SRBCs.

The study explores the effects of SRBCs on students' responses to science from the perspective of three different groups of people: key informants (government staff, SRBC funders), teachers and students. A series of case studies was carried out in six residential schools in Malaysia. Data were gathered from four key informants, six teachers and 360 sixteen-year-old student participants, divided into six groups, in Form 4 of secondary school. Students' responses to science were explored in a number of ways. Data on attitudes towards science were gathered through the Relevance of Science Education (ROSE) questionnaire, and the findings are compared with those of the ROSE National Survey Data for Malaysia carried out in 2004. Additional data were gathered through interviews with students and from student diaries.

Students in residential schools showed more positive responses to science in a number of areas when compared with the ROSE National Survey Data. In particular, students expressed a preference for jobs which favoured recognition after accomplishing challenges, and which offered creative tasks. In contrast, they shared similar views to those found in the national survey towards school science.

The study indicates that SRBCs deepen students' interest in pursuing science and create an ability to apply knowledge which is related to it. The students

reported that science is much more enjoyable when it involves autonomous learning and research activity. Students were influenced by their mentors (the teachers running the SRBCs in their schools), the types of project and the degree of external involvement. The teachers reported positive developments in their students' science processing skills, and their knowledge and awareness of science in general. The students also developed confidence in time management, communication and handling stress along with the project. This represents a revealing insight into the views of the three main components of SRBCs; the organisers/sponsors, the practitioners and the participants.

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Acknowledgements

Alhamdulilah (thank you, Allah)

I would like to mention, in bent-kneed gratitude:
my teachers, Professor Judith Bennett, Fred Lubben, Professor Chris Kyriacou and Professor Robin Millar: you have all been a wholesome example. Your encouragement, support, help and also comments on the study as well as on the drafting of the chapters has been really helpful and encouraging. Thank you for the huge support you have given to me.

Secondly, I would like to thank the key informants, teachers, school administrators and students who agreed to participate in the study. Your valuable experiences, the time you gave me and your commitment towards the programme and to this study are highly appreciated.

Thirdly, I would like to thank Roger Witts, who wisely gave me helpful comments from the perspective of someone outside the field of science education, and for his endurance in proof-reading my chapters.

Fourthly, I would like to thank my family back home: Liza, Mahmod, Helmy, Suhana, Erwan, Azlina, Mohd. Salleh, Amir, Eiman and Imad, for their moral support, love and trust in my academic venture. Your support is the strength for me to move on.

Finally, I would like to thank the Ministry of Education Malaysia for granting me the scholarship to study a subject which is dear to me in the University of York, United Kingdom. This is an honour which I shall treasure and serve for the betterment of our nation.

I would like to dedicate this thesis to the two inspirational people to whom I owe most for my interest in education and in life: my late father, Hj Amri Hasbullah, a teacher, and my mother, Hjh Jemilah Atan, a believer. Your love, guidance and inspiration are the reasons for the accomplishment of this mission.

Terima kasih (Thank you)

Declaration

The research presented in this thesis is, to the best of my knowledge, original except where due reference has been made to other author's and/or co-workers.

Some of the material contained in this thesis has been previously published by the author; where items were published jointly with collaborators, the author of this thesis is responsible for the material presented here. For each published item the primary author is the first listed author.

Signed ....

(Nita Siti Raudhah Amri)

Date **21 October 2013**

Chapter 1: Introduction

> *"Printing, gunpowder and the compass ... whence have followed innumerable changes, in so much that no empire, no sect, no star seems to have exerted greater power and influence in human affairs than these mechanical discoveries."*
>
> Francis Bacon 1620 in *Novum Organum* (Bacon, 1923)
> retrieved 12 October,2010 from,
> *http://historygallery.com/books/1740bacon/1740bacon.htm*

Science and technology (S&T) have played a major role in lightening the burden of human beings and solving many of the daily chores of life. Consuming science and technology is enthralling as it changes difficult jobs in just the click of a button. It brings revolution, industrialization, world war, a knowledge boom and globalization into our lives. Currently, most of our life decisions rely on weighing scientific arguments against value judgements. This includes selecting treatments for diseases, evaluating current natural phenomena, understanding climate change or operating new technology.

Just being a complacent and passive S&T passenger, however, eventually diminishes the expansion of science and innovation to a higher stage. To an extent, a society which is scientifically illiterate will be easily manipulated by propaganda. It is therefore the responsibility of every nation to develop and sustain its people's interest in science. Nourishing the minds of the young into curiosity about science and technology is an obligation and a strategy for every nation in order to survive and to succeed in its future undertakings.

1.1 The Current Global Science and Technology Scenario

A number of concerns have been raised about the decreasing number of science students in the secondary and tertiary levels of education globally. From recently collected data, there is a massive drop in the number of students in the developed countries who are opting to study science in their secondary schools and who have taken science at tertiary education level. Interest in science is also found to be falling especially in well-developed countries such as the UK, Japan, Finland, Denmark and Norway (Schreiner & Sjoberg, 2005). On the other hand, Uganda, Swaziland, the Philippines, India, Malaysia and Greece (which are grouped as developing countries) are showing increased interest in science and technology. From the same study, the researchers identified that the interest shown by young people is a reflection of what they perceive to be essential to them and their society. A student's choice of career is very much related to the issues which he/she perceives to be imperative and worth pursuing. The pronounced interest of young people in developing countries for careers in S&T might be due to their belief that S&T is vital in promising better wealth and health and bringing benefit to all (Schreiner & Sjoberg, 2005). It is therefore meaningful for them to become engineers, technicians, researchers and scientists for the benefit of their country's pride and prosperity. However, the late-modern societies which are characterised as being post-materialistic societies (Inglehart, 1990) have less interest in science as they have a different perception of the issues which are vital nation-building tasks. They show more interest in environmental issues and health. According to Galama (2008) the reducing numbers of citizens in scientific fields in developed countries increases reliance on foreigners in the workforce, and jeopardizes economic growth and the citizens' standard of living, as well as national security. It reduces the pool of expertise in various critical areas, especially in handling nature-related issues, safety, the environment and international security.

To address these issues, collective efforts by researchers, government and independent organizations have been made to determine the main cause of the decline and to develop understanding of the phenomenon from various perspectives. Studies of students' needs, gender differences (Schreiner & Sjoberg, 2005), curricular change, pedagogical approaches and patterns of learning have been undertaken in order to reduce and compensate for the fading interest amongst students. Suggestions have then been made and tested to confirm the validity and effectiveness of the studies. Good practice has been shared and suggested for others to follow. At the same time, governmental and non-governmental agencies have come up with various efforts to sustain interest among school children towards science. New grants, science bodies and strategies have been collaboratively introduced in order to ensure the production of a sufficient and skilled work force for sustaining the development of the nation. Nevertheless, the most crucial agenda is to expand the pool of elite scientists which will be providing a firm basis for national competency and inspiration for the years to come.

The demand for a continuous ‘pipeline’ that will supply a steady stream of scientists and engineers to the workforce by moving raw talent through ever-higher levels of educational attainment is vital (Marret, 2009). Losing capable higher-level students along the pipeline will reduce national competitiveness, while missing middle-capability students will lead to a loss of scientific literacy among the population, and dropping the weak students will certainly widen the gap between the higher and lower levels of society. Incentives in the form of monetary enhancement, promotion, perks and a better infrastructure should be available to those who have higher capability and are eligible to ensure national competitiveness. In due course, all these factors would accelerate the development of interest, motivation and confidence amongst the brighter young people in venturing into science for their future careers. Wider exposure for the less-able students will ensure that they perform as well as possible the future citizenship needs. In this way, national development will continue to grow progressively with time.

With the increasing reliance on science and technology, the more dependent and flexible it needs to be in order to meet future citizenship needs. The young people who will become the scientists of the next generation are important human capital both for national development and for world harmony. They are a potential national asset, responsible for seizing the opportunity for any particular country to be a powerful leader in S&T and consequently controlling the economy and the work force, as well as contributing to world peace. They are responsible for innovating and adapting new technologies to employment, production and sales, and for establishing the strength of the economy and standard of living. S&T deteriorates when many young people seem to develop ambivalent attitudes towards it.

According to Galama (2008), S&T in the US has historically contributed significantly not only to the US economic growth but also to the well-being of Americans in terms of improved public health, longer life expectancy, better diagnosis and treatments of many illnesses, and so on, and in the standard of living and national security. As a consequence of being the top most scientific and technological country for years, the strength of the US economy and military capability permits them to have a strong authority in global leadership. This logical statement has led to a diagnosis that science and technology are linked not only to contributing to the country's economic strength but also to its global strategic leadership.

The emergence of new aggressive power in science and technology in countries such as China, South Korea and India from the east has disturbed US stability and increased American worries tremendously, causing them to be more proactive in research and innovation in order to sustain their title and recognition. Losing their grasp on world leadership in science and technology will eventually diminish their credibility in world economic leadership. S&T leadership has a definite inter-relationship with economic power; and a country which has it subsequently enjoys the supremacy to lead the world.

Research and innovation is a crucial entity in science and technology, as no programme development could flourish without proper planning and persistence in research and innovation. Being just a docile consumer of science and technology will only lead to despair for a nation's future in terms of independence and progression for betterment in economy, security and quality of life. Realizing this, the developing countries are competing progressively in order to launch themselves onto a secure platform. They are committed to producing a viable and elite workforce in science and technology for the continuous progression of the nation.

Evidence from the developed nations shows that science and technology uptake depends on at least two aspects; achievement in science and technology at school and responses to science and technology.

According to The Relevance of Science Education study (ROSE) 2005, students' attitudes towards science in developing countries are much higher compared with those in a developed country such as the US, Japan and European countries. Analysis has shown that those who come from well-developed countries have little interest in science, do not like school science, refuse to become scientists and have no interest in becoming involved in the technology sectors. On the other hand, students from less-developed regions show positive attitudes towards science, have an interest in science at school which is greater compared with other subjects, and they would like to become scientists and be involved in technology (Schreiner & Sjoberg, 2005).

Students' responses to science would be a useful indicator in predicting the future development of the S&T of any particular nation. It can predict the choices of subjects taken in higher secondary school and at tertiary level and subsequently, students' career choices. Currently, India, China and South Korea are the three top countries which are consistently increasing the number of their science and engineering students in US higher education institutions. Although India showed a decline of 17% in her enrolment in science and engineering subjects in 2009, the number of students is still the highest, at 67,800 enrolments per year. On the other hand, China increased her students in 2009 to 53,740, representing 25% more enrolment than in 2008 (Burreli, 2010). Currently, there are 12,930 students from China and 47,170 students from India enrolled on master's courses in various science disciplines, while 29,490 and 14,230 students from both countries respectively had enrolled on their doctorates in autumn 2009. The UNESCO UIS report published in October 2010 showed that most of the science researchers in the world originated from the Asian region. This is an increase from 35.5% in 2002 to 40.9% in 2007. Nevertheless, the US still has the greatest number of researchers in the world (1,425,550) followed by China (1,423,380) and Japan (709,974), (UNESCO, UNESCO Institute for Statistics, 2010).

The seriousness of any government and its people in creating new progress in science and optimizing its national human potential will surely produce greater numbers of future professionals in science, engineering and related fields for the forthcoming generations. Investment in R&D indicates the enthusiasm of a nation for its development and progress in science and technology. In sum, the more literate a nation is in terms of science and technology, the more research and innovation will be developed accordingly and the more powerful and developed the nation will become.

1.2 The Science and Technology Scenario in Malaysia

In 1991, Malaysia established a visionary policy, entitled Vision 2020, the aim of which was to transform the developing country status into a developed nation by 2020 (Malaysia, 2008). The key strategic challenges presented in Vision 2020 included establishing a united nation, creating a mature, ethical and effective inclusive democracy, and establishing a caring and economically just society. There were nine main missions stated in the Vision 2020 blueprint. The sixth of these challenges in Vision 2020 was the challenge of establishing a scientific and progressive society, a society that is innovative and forward-looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future (Malaysia, 2008). Based on the demand for economic growth and strong progress from the late 1980s until the mid 1990s, Malaysia's annual gross domestic product (GDP) growth was an impressive 9%. Between these periods there has been tremendous reduction of poverty and an enhancement of living standards and life expenditure on living costs in 2008, per capita GDP was USD 15,7000 and the growth was estimated at 5.5%. Based on the strong economic momentum which built up during that period, there is a positive signal that achieving the targets on time is feasible. In order to contribute to the scientific and technological civilization in the near future, developing a knowledge-based economy has been set as an efficacious solution. This runs parallel with speed and the secure repositioning of

Malaysia alongside the other developed nations. This requires a higher level of education across the population in order to enhance the human capital and the productivity of workers, and creating a culture of innovation and dynamism to strengthen both individual and institutional capacities (Mokhsein & Ahmad, 2009).

To cope with the great challenges and demands of this aim, Malaysia has therefore outlined a policy implementation framework that details the country's priorities and strategies for the next few years. This is called Malaysian Plan. The Malaysian Plan is a long-term (five-year) plan established by federal law and formulated by the Economic Planning Unit of the Prime Minister's Department. It has been created to administer and manage the Outline Perspective Plan (OPP). The Outline Perspective Plan spans a period of ten years. Currently, Malaysia is in her Third Outline Perspective Plan (2001-2010).

The Third Outline Perspective Plan (OPP3) focuses on building a resilient and competitive nation towards the realization of Vision 2020. It has highlighted the need to strengthen the nation's capacity and capabilities in education, and resolves to meet the challenges to come. A highly-educated workforce is extremely crucial in building and driving the knowledge economy. A target has been set of a 60:40 ratio of science students to arts students. More science students are needed to guide the nation towards the production of a sufficient workforce and capable leaders in science and technology. In 2004, the percentage of graduates in tertiary education was 23% in engineering and 21.3% in sciences, but in 2007 the percentages had increased to 28% in engineering and reduced to 17% in sciences. Given this inconsistency, the targeted ratio of 60:40 science to arts seems to be a difficult target to obtain: a less-skilled work force is being produced and, in turn, this jeopardizes the attainability of the inspired target which has been set.

Malaysia produced 23,092 science and engineering researchers in 2004. This figure comprised 24% researchers in natural science, 42% in the engineering sector and only 7.4% in medical sciences and health. In 2006, few changes in these percentages appeared: there were 25% of the 19,021 researchers who were actively involved in natural sciences, 41% in engineering and 9.6% in medical sciences and health (UNESCO, Beyond 20/20 WDS table view Education data, 2010). There were only 372 researchers per 1,000,000 of the population in 2006 (UNESCO, UNESCO Institute for Statistics, 2010). Compared with South Korea, Malaysia was fifteen times worse in producing researchers in engineering in 2004 and twenty-four times worse in 2006. According to the statistics, Malaysia had fewer researchers in engineering, medical and health sciences. There were only 42% of Malaysian researchers in 2004 and 41% in 2006 who were involved directly with research in engineering compared with her nearest neighbour, Singapore. Singapore showed more researchers working in engineering in 2004 and in 2006, at 64% and 61% respectively. Medical and health sciences showed even more differences in that Malaysia produced only half of the researchers in those fields that Singapore did. At present, Malaysia lacks the critical mass of qualified scientists, engineers, and medical and health science and related professionals to comply with the k-economy. The k-economy is based on a paradigm that focuses on intellectual capital as a prime mover. With knowledge replacing physical and natural resources as the key ingredient in economic development, education and human resource development (HRD) policies require rethinking (Ramlee & Abu, 2004). To be on a par with the developed nations in 2020, more strategies for stimulating science, technology and research activities need to be implemented in the young people of Malaysia before it is too late.

In response to the current situation in Malaysia, the Malaysian government Malaysia (2008), has outlined some strategic measures as stated in the ninth Malaysia Plan (2006-2010),

a. A holistic programme for the national mission. It aims to enhance the nation's capability to compete globally, to strengthen national unity and to bring about the better distribution of wealth and income, and a higher quality of life for the people.

b. Strengthening human capital and bringing about a cultural and mindset change. This involves human development and training, encompassing knowledge and ethical values, a progressive mindset and cultural awareness.
c. Reviewing the curriculum, increasing the teaching and utilization of ICT in schools and enhancing teaching skills. The government has wisely set up a Multimedia Super Corridor (MSC) in 1996. The purpose of this is to enable the country to leapfrog ahead into the latest technological frontiers with many implications for educational development and priorities (Brunnel, 2004).

Comprehensive educational plans have been clearly articulated in Malaysia's Five-Year Long-Term Perspective Plans. In 2001, the Ministry of Education produced its own blueprint called the Educational Development Plan (2001-2010), containing detailed educational goals, priorities, programmes and projects. One of the major recent policy reforms was the use of English as the medium of instruction in the teaching of science and mathematics in schools (ETEMs). This was introduced in 2002 in order to increase students' proficiency in English (Ismail, 2009), thus reducing the knowledge gap in science and technology. However, this attempted innovation attracted a great deal of debate especially amongst nationalists, academics, politicians, policy makers and parents after six years of implementation. One of the strong reasons for rejecting the idea was because of TIMSS performance in 2007.

Malaysian students' performances in science and mathematics were tested internationally by participating in the Trends in International Mathematics and Science Study (TIMSS) in 1999, 2003 and 2007. Malaysia has decided to participate in the Programme for International Student Assessment (PISA) from 2011 onwards. Records show that students' performance in 2007 had deteriorated badly compared with 2003 (TIMSS, 2008). Significantly serious decline in quality appeared in both subjects. In mathematics, Malaysia was ranked tenth in 2003, with 508 points and doing very well above the international average of 466. Malaysia outperformed some of the developed countries such as Australia, the UK, the US and New Zealand. Regrettably, the ranking dropped drastically to twentieth in 2007 with 474 points, below the average international score of 500. This severe drop automatically reflected the downturn in ETEMs. For sciences, the ranking dropped from twentieth in 2003 to twenty-first in 2007. The score was 471 which was below the average of sixty countries. The irony is that although students were taught in English for both subjects in 2007, their performance was significantly lower than when they were taught in Malay. Unreservedly, this is an alarming indicator of the reducing competencies in science and mathematics amongst students. Accordingly it has jeopardized the national target of 60:40 as this represents the result of the first cohort out of five that underwent learning science and mathematics in English.

New strategies were then put in place by the Ministry to amend the mistakes. A revision of the policy was made in 2009 as the Ministry found that students' performance in science and mathematics subjects had deteriorated since the subjects were taught in English. They attributed this to the teachers' and students' lack of proficiency in English, which had made it all the more difficult to understand the explanations of science concepts in English and this therefore widened the gap.

As the end of the Third Outline Perspective Plan is approaching, reports and reviews on the national achievement have been released and discussed. Most recently, a report from the National Economic Advisory Council (NEAC, 2010), stated that the weak productivity growth in Malaysia resulted from weak innovation and creativity. The weak track record of domestic innovation in Malaysia is reflected in the low number of researchers. It is a result of the lack of a programme for developing talent. The innovative and creative effort is still insufficient to sustain progress towards productivity. The emigration of talented Malaysians abroad is rising rapidly and there is a declining number of expatriates in Malaysia. "Globalisation has a fierce competition for talent, forcing companies and the government to recognise that people are the most valuable assets. To compete on a regional and global scale, Malaysia must retain and attract talent" (NEAC, 2010) p. 3. Consequently, it is advised that the education system in Malaysia needs to be changed from ‘rote learning’ to ‘creative and critical learning’ fast, as the time is running short.

A different approach to handling the shortage of science students compared with arts students needs to be addressed wisely and a new approach needs to be formed. The strategy of enforcing more Malaysian students into doing science at tertiary level should not solely depend on the number of students enrolled into the science stream after the National Lower Secondary Examination; instead, it is more practical to instil an interest in science, technology and research discipline through everyday life experiences.

Research on the uptake of science and technology careers had identified a few attributes that might stimulate students’ interests; knowledge, skills, experiences, attitudes and motivation (Woolnough, 1994). However, attitudes and motivation were the most important drivers for students’ interest towards pursuing science. With sufficient and appropriate school experiences, the students gained appropriate positive attitudes and motivations towards school science (Yager *et al.*, 1989). Therefore, schools are responsible for providing sufficient able students who are into science or technological careers. This can be achieved through teachers’ enthusiasm for science, science teaching and extracurricular activities which incorporate science and research activities.

All schools should work on some initiative to increase the amount of interest and the numbers of students in science, especially among those students with high capabilities. To achieve that, having science research-based activity during the co-curricular (after school) programme is believed to be one of the alternative options. It forges confidence and motivation and enhances students’ interest in science and technology through their involvement in the applied sciences related to their observation of nature and their everyday experiences. Consequently, this gives the students a better idea of how to incorporate contextual knowledge from the classroom into something which they can apply to explaining the natural world which they see around them. By understanding and learning science actively, students will unravel their fears, develop creative thinking and hopefully have higher self esteem in pursuing science and research in their future undertakings.

1.3 Science Research-Based Competitions (SRBCs)

Collaborations between governments and the private sector have been established for years. They have been working hand-in-hand to ensure both a sufficient flow and an appropriate quality of workforce produced by the system. One of the most popular programmes which has been around since 1934 is Science Research Based Competitions (SRBC). These are competitions that encourage active research, investigation or experimentation, involving innovation and new findings or knowledge of new improved products, ideas, processes or services. Science research-based activities are also known as high-end research and grow originally from students' initiatives. They raise questions and make an attempt to understand and clarify their early guesses at solutions, and eventually they will come up with sensible and sound explanations for largely unknown and undeveloped nature-based issues. This prestigious programme consumes hundreds of millions of dollars each year in organizing, judging and conducting the competitions, and providing prizes for the winners. Currently, Intel has allocated over four million dollars just to award to the winner of the Intel ISEF 2010 (ISEF, 2010) while the Siemens Foundation and College Board allocates seven million dollars each year for its project winner, and Toshiba spends more than a million dollars a year on organizing its science research competitions which have been held annually since 1990. The monetary award granted is a token to stimulate a passion for research, especially among the most capable students. The selected winners are given opportunities and a specific amount of money to continue their research, expand their interest in their field, and pursue their studies in science fields. There are many organizations which have been committed to helping nations to foster and promote science as a part of their social contribution activities. A great deal of funding has been gathered in the hope of stimulating and attracting high-achieving young people into elite science and engineering fields globally and motivating the rest into the field eventually.

Science competitions can be divided into two distinctive structures, one of which involves applying the usage of multi-science disciplines in order to solve or create sets of given tasks, while the other is based more on a specific area of science, such as the Chemistry Olympiad, the Biology Olympiad and the Mathematics Olympiad. The applied multi-science discipline competitions cover Robotics, Innovation and Engineering, Rocket Launching, F1 in schools and many other fields.

Historically, science competitions started in Russia in 1934 and were initially used as a tool for segregating the most talented and gifted students across the nation. The selected students then were put into intensive teaching programmes and trained to become elite scientists and researchers. This helped to speed up the creation of a pool of potential scientists for Russian science and technology development. Currently, the activity has been wisely replicated by the emerging dragon from Asia. Korea has been seriously involved in science competitions since 1949. Korean scientific ability improved dramatically with their continuous commitment to science, and the country also organised two other large events, the National Students' Science Innovation Fair in 1979 and the successful first International Science and Engineering Fair in 2010. Through these events, they were able to attract 26,669 contestants (Korea National Science, 2010) who generated newly developed ideas and potential patents to be granted to the young inventors yearly. In consequence, they have successfully instilled the importance of science and mathematics into their culture and into Korean people's minds and have achieved recognition from neighbouring countries for their success.

Today, science competitions have become a trend and are regular annual events throughout the world. They involve various kinds of challenge which are designed for different types of ability level and different age groups. The benefits and the hidden agenda behind all this have become indistinct despite the huge amount of effort, time and money invested yearly. Taking part involves motivation, determination and pride. Winning an international fair is everyone’s aim. To be selected in an international arena certainly brings satisfaction, motivation and confidence to the participants. To enable students to compete at the international level, smaller competitions are organised at lower levels to select the most capable participants and projects. The best contestants would be selected over a period of time and groomed to represent the pride of their country. The majority of the participants and winners come from high-profile schools which have the facilities and ethos to deliver S&T effectively and work collaboratively with nearby local university laboratories.

Fully Residential Schools have shown outstanding performance in science competency in Malaysia. They have been continuously presenting Malaysia to the international community and winning friends for the country over the last ten years. With the advantage of being able to gather the best students from all over the nation under the same roof, the residential school system has all it needs to create and prepare the best candidates for any task. Each year, the students will come up with interesting projects which are strongly supported with sound scientific data.

1.4 Fully Residential Schools (FRS) in Malaysia

1.4.1 A historical perspective

Fully residential schools (FRS) in Malaysia represent a unique schooling system which was originally established in 1890 when R.O Winstead was the Deputy Director of Education in Malaya. It was an initiative to educate the royal elite and the children of Malayan Chiefs in an English style of education. In 1903, the Sultan of Perak at a conference of Rulers (a Durbar) criticized British administration policies, especially in the education of the Malays, by saying that it was merely a system “for producing better fisherman and Malay farmers”. Consequently, land was generously donated by the Sultan and the first Malay residential school was set up in 1905, and is still known as the Malay College Kuala Kangsar (MCKK). It aimed originally to train Malay boys for admission to certain branches of government service. Then, in 1947, the first Malay girls' college was officially opened in Kuala Lumpur after being delayed for a few years due to the Second World War. More FRSs were then built across the country; six in 1955 and ten more in the 1970s. It was the ambition of the nation in the Malaysia Second Policy Plan (1970) to provide additional educational opportunities for pupils from rural areas to pursue their education in science subjects. This pilot project has successfully built up the number of indigenous people who have been trained and groomed to work in the sciences and in managerial posts. It has accelerated the progress of development in Malaysia. Currently, the FRSs continue to expand and there are now 59 FRSs which accommodate 35,935 students and represent a composition of 30% urban: 70% rural.

1.4.2 The objectives of FRSs

One of the stated goals of the system is to create educational opportunities within a complete and modern school environment which is conducive to nurturing students' potential and developing their talents especially on science orientation in preparation for national needs and Vision 2020. A great deal of planning, effort and resources have been mobilized to ensure the success and continuous growth of FRSs and the contribution of FRSs towards the development of the nation. There are two types of entry to the system. The first is when students enter Form 1 (grade seven) and the other is when they go into Form 4 (grade nine). Both entrance routes are based on the students' national examination results, involvement in co-curricular activities, leadership and interviews. Only 15% of the 40,000 qualified candidates are selected to enter the system each year. Those selected have the most potential of all the students of the nation and are the most valuable human capital for the country.

1.4.3 Types and system

The FRS system in Malaysia provides academic excellence as well as a home for the selected students. Students come from various walks of life and are gathered together to assimilate their talents according to the national aspirations. They are given ample opportunities to develop their talents and mingle with peers who have about the same capabilities and interests as themselves. On the academic side, they are taught by reputable selected teachers who are committed and talented in their own subjects. They are able to choose to learn an extra foreign language which appeals to them most. The languages offered are Mandarin, Japanese, Arabic, French and German. By this means, it is hoped that they will be more marketable and valuable to meet national expectations.

There are two types of fully residential school in Malaysia, single-sex and coeducational. The academic subjects taught in these schools are the same as in the other national schools, but some of the schools are designed for students to continue their study in pure science subjects or in a mix of science and technical subjects, and others offer a mix of religious and science subjects. The teachers engaged to work in these schools are among the best in their fields, and this is particularly important as great emphasis is placed on excellent academic achievements.

As they spend most of their time within the school compound, a tailor-made discipline structure and curriculum have been design to be adhered to by all students. They are considered ‘special’ and are educated closely to match the country’s educational aspirations and socio-economic and political development. Fully residential schools in Malaysia are under the direct supervision of the Ministry of Education, unlike the other schools which are under the jurisdiction of the respective State Education Departments. Because they are designed to cater for the nation’s future leaders and represent the nation’s biggest human investment, the per capita running costs for each FRS are four times higher than those of ordinary schools (Mat, 1993). With the new clustering and excellence programme launched by the Ministry of Education in 2008, more benefits have been allocated for these schools to optimize their students’ potential. Some schools are selected to be in the new cluster schools and these are those which have a long record of success stories in their specific niches. These schools are granted more funding and greater autonomy to develop and flourish their niche areas, so for them, the sky is the limit.

With globalisation, fully residential schools are being encouraged to build up links with overseas schools. They are encouraged to join a twinning programme with globally-linked schools, their current ICT facilities are upgraded and more opportunities are provided for smart collaboration with higher education institutions for research purposes. This opens up the capacity to identify and develop the students' potential in various aspects of their talents and gifts. Specialities in some niche areas have also been established and recognized by the Ministry. Exposure to the international atmosphere is provided gradually in order to increase students' self-confidence and motivation and provide a model for their development. The system is doing all it can to open up the schools to meet real challenges and world expectations.

Because of this focus and the future-orientated aspects of its agenda, the FRS system has laid a sound basis for its eight-year plan (2008-2015). The schools are committed to producing students who match the nation's needs and international demands (Abdullah Sani, 2008). Accordingly, FRSs have responsibility for creating quality educational opportunities with a complete and conducive learning environment geared to the students' potential, especially for those who come from rural areas. It is the intention that these students will reduce the gaps in the social economy between the current rural and urban communities. This will create wider opportunities for prospective rural students to be developed into future Malaysian leaders with excellent personalities and high self-esteem, knowledge and skills and a sound ethical base. They are the ones that are also likely to fill the posts of much-needed scientists and technologists in the years to come. The training and the programmes lined up for them will initially establish a sound base and influence their attitudes towards life, education and the future. FRSs have been found to provide the best settings in which to cultivate good national values and inspiration for preparing future leaders. In short, they represent the national hope and aspiration.

With the facilities available to them and their own talent, students in these schools are exposed to a wide variety of activities, such as academic work, sports, leadership, music, performance art, and research and development. There are many competitions, programmes and camps in various disciplines all year round. These activities not only develop the students' leadership training but also enhance their talents in specific areas and consequently teach them time management. One of the most prestigious activities is science research. They have their own science and engineering fair. This has been the most popular and challenging amongst the students and schools in the FRS system since 2000. Without fail, each school will develop two projects to compete amongst FRSs each year. The winner of the competition is judged according to the standards of the International Science and Engineering Competition as conducted by INTEL. The winner will normally compete in the National Science Competitions to contend with other national schools in order to secure a place at international level.

Science research competitions provide ample opportunities for residential school students to make sense of science by explaining complex issues and using the power of technology to provide a window on scientific processes. This guides students to explore compelling problems and provides valuable experience for students to sustain their interest in science and promote lifelong learning. This activity is aligned with the aspiration of cultivating an interest in science among pupils, as stated in the second Malaysian Economic Plan: *"an important project in the plan is the establishment of ten pilot residential secondary science schools to provide added educational opportunities for pupils from rural areas to pursue their education in science subjects"*. In view of the fact that recruitment to S&T is a key factor in global competitiveness, a great deal of money, effort and initiative has been put into improving the situation.

1.5 The significance of this study

Since they were launched in 2000, science research-based competitions have successfully attracted thousands of interested students and used millions of Malaysian Ringgit each year. Up to the present, however, there has been no study carried out in Malaysia designed to understand the impact of the programme on students' attitudes towards science and to assess the achievement of the competitions' objectives. Furthermore, there have been no post-action, recognition or programmes established for the winners. The emergent talent has been neglected and is being wasted.

The overall purpose of this research study is to contribute informed and critical reflection on the impact of conducting science research-based competitions amongst residential school students as well as to collect and analyse empirical evidence on their responses to science. It is hoped to stimulate an informed discussion and possibly to suggest policy measures and feasible changes and improvements in conducting science research competitions, mainly amongst the fully residential schools students, but also in other interested high-performance schools. The project therefore has theoretical as well as practical concerns which are not confined to residential schools but can also be extended to the national schools as a whole.

1.6 Aims and questions of this study

The overall aim of the study is to examine the impact of science research-based competitions on students' responses towards science. The impact will be measured in stages: first the overall responses to science amongst a sample of the residential schools population compared with the nationwide sample is measured and analysed. Results collected will be used as primary data which will lead the study to a deeper understanding of the current higher achievers' responses to science and factors contributing to them. This is also a starting point for understanding the overall perception of science amongst the most highly talented students in Malaysia. The general impact of certain factors such as types of school, gender and types of activities which are anticipated to contribute to their perceptions of science will be discussed in detail. Attention will then be focused on what is revealed by the results.

Further discussion follows to draw together students' perspectives on the science research competitions from various aspects including students' experiences, their likes and dislikes about the work associated with the competitions and their explanations of why they feel this way, the extent to which their experiences have or have not influenced their career choices, what they like more and what they like less about science as a result of participating in the competitions, what sort of support they have had from teachers and mentors, and their confidence levels and their views about working in a team. A conclusion on the gathered data will then be summarized in the final part, assessing the impact of the activity in four particular areas; the ability to take up challenges, understanding science, pursuing careers in science and attitudes towards science and technology. Teachers' perceptions will be used as additional information and confirmation of the claims and complaints made by the students and the findings will be compared with the aspirations held by the key informants.

It is hypothesized that by being educated in an institution which gathers the best students from all over Malaysia and exposes them to recent achievements and S&T developments through easy access to information and technology around the campus, residential school students in Malaysia will have more positive responses towards science compared with national-school students in Malaysia. Millions of Malaysian ringgit are spent each year by the Malaysian Ministry of Education, by the private sector and by other government agencies to sponsor and organise the science competitions. It involves a great deal of time and effort from various parties in order to motivate enthusiasm for science among students. These programmes have received positive responses for many years, especially from the fully residential schools. Accordingly, participating in science research based competitions must have a significant influence on the responses of FRS students to science. Each year, teachers spend time with the selected interested and bright students to help them to accomplish their science projects across the nation. Despite the absence of any promise of extra financial support, this has not stopped the teachers from putting continuous effort and drive into recruiting new participants. Teachers' continued involvement makes it clear that they foresee the changes that can be achieved, that students who have participated in science research based competitions have developed greater responses towards science in general and towards taking up science challenges, understanding science and pursuing careers in science.

Science research based competitions are the main channel by which students in fully residential schools can be directly involved in science activities, so it is hoped that this research will answer the following questions;

1. What responses to science are held by sixteen-year-old students in Malaysia?
2. What are the effects of science research based competitions on students' responses to science?
3. What are the views of sixteen-year-old students of the effects on them of participating in science research based competitions?
4. What are teachers' views of the effects of their students participating in science research based competitions?

Note that all the data used in this research were collected from students and teachers in fully residential schools in Malaysia.

The main sources of information for this study were a questionnaire on attitudes towards science, in-depth interviews with the participants and their mentors, and diaries kept by students during the research period.

1.7 Limitations of this study

The principal limitation of this study is that as the research was carried out through a series of case studies in selected fully residential schools in the heart of Malaysia, it is not meant to be generalised to all schools in Malaysia, in other developing countries or to schools in any other part of the world.

A further limitation of the study is that it was carried out at a micro level, and is mainly concerned with the responses and the science participation experience of high-achieving students who have been in the residential school system for at least three consecutive years. A conscious effort has been especially made to form a conceptual link between the macro and micro levels throughout the study by using the concept of science competition type, which itself embodies both the thinking and the procedures involved. Nevertheless, the study does not attempt to explain or account for students' different abilities in Malaysia. The focus of the study is on specific aspects of the process by which science research-based competitions are conducted and participated in amongst the higher achievers in residential schools in Malaysia.

1.8 The structure of this study

The first three chapters provide the general setting for the investigation by describing the research problem in Chapter 1 and reviewing the relevant literature in Chapter 2, which comprises literary reviews depicting the manner in which students' attitudes towards science differ between science as part of school activities and science outside school participation. Chapter 3 elaborates on the science competitions; the history, aim and effects of organising them. Chapter 4 presents the methodological approach for the school questionnaires, interviews and diary keeping. It describes the research design, sampling strategy, data collection procedures, measurements of variables and data analysis.

The remaining chapters present the empirical results of the study. Chapters 5, 6 and 7 analyse the overall responses towards science amongst the residential students. Chapter 5 gives an overview of the expectations of sponsors and the Ministry of Education. Information used in the chapter is gathered through the analysis of the in-depth interviews with the key participants. Chapter 6 elaborates in greater depth on the findings of students acquired from the questionnaire, diary keeping and the interviews. Teachers' views are drawn together in Chapter 7, and these support the information provided by their students.

Chapter 8 presents the conclusions and implications of the study. It considers the overall impact of participation in competitions on students' responses to science in terms of the four research questions. The inter-relationships between factors used in the study are discussed. These factors are investigated through the explanatory model developed for the study. The main conclusions and implications are drawn together for policy makers, for school administrators and for programme organisers.

Although there are many positive perceptions of the impact of SRBCs discussed in the early chapters, the reality of the situation is also revealed as the discussion progresses. The dilemmas, pressures, hopes, stresses and dissatisfactions emerge subsequently and these colour the understanding of the overall effect of the programme.

Chapter 2: Attitudes towards Science

Overview

Students' enrolment into science subjects compared with non-science subjects after completing their lower secondary education in Malaysia increased from 27% in 1995 (MOE, 1997) to 39% in 2002 (MOE, 2002) and again to 45% in 2010 (MOE, 2010). However, over fifteen years (1996-2010), the numbers of students who continue to pursue their studies in the science stream after their upper secondary stage remain low, approximately 30:70 (MOE 1997; 2002; 2010). The failure of the numbers to progress against the national projection of 60:40 in 1997 has raised serious concern in the Malaysian government. The consequences are that it not only reduces the size of the skilled workforce forecast but also that it slows down the process of Malaysia becoming a developed country by 2020. The crucial question is about what causes students not to choose science and to lose their interest in science during their secondary schooling years. Does it confirm the views of Head (1985) and Bandura (1986) that people's choice of activities is based on things that they presume to be interesting, rewarding or worthwhile in some ways? Or perhaps the declining interest amongst students aged seventeen and over in Malaysia is due to their previous experiences of the subject, the expression of opinions by others, images portrayed in the media or self-perceptions about their own ability and intellectual competence. But students' attitudes towards science cannot be blamed solely for the stagnant progress of science enrolment since their decisions are influenced by and closely related to the curriculum, teachers, gender and personal perceptions of the level of subject difficulties (TRS, 2008). Therefore, close examination of the major factors needs to be carried out in order to fully understand the issue which has arisen.

2.1 Definition

An attitude can be described as a result of pre-knowledge, and beliefs gathered by self-experience or observational learning on particular objects have been found to influence a person's attitude towards an object (Gardner, 1975). According to Head (1985), attitude can be regarded as an underlying generalised construct which is made up of individual experiences and events encountered. It is a decision made upon individual interpretation and personality. Opperhiem (1992) defined attitude as follows

> ... attitudes are normally a state of readiness or predisposition to respond in a certain manner when confronted with certain stimuli ... attitudes are reinforced by beliefs (the cognitive component), often attract strong feelings (the emotional component) which may lead to particular behavioural intents (the action-tendency component). (p.175)

The definition was summarised by Bennett (2003) as a function of what an individual knows, how an individual feels about something and how it influences individual behaviour. Other definitions include that of Kind *et al.* (2007) who described attitude as the judgement or feelings that a person has about an object, based on his or her knowledge and belief about the object. In summary, attitude can be concluded as being constructed on a tripartite model: ABC – affective, behavioural and cognitive (Bagozzi & Burnkrant, 1979; Barmby *et al.*, 2008,). Accordingly, in order to yield a meaningful and valid interpretation of attitude, these three components need to be assimilated (Bennett, 2003). In this current study, attitude towards science is regarded as the individual perspective towards science and technology as a result of influences and the effect of various life experiences. Subsequently, as the study includes an evaluation of the attitudes and skills involved during the competitions, 'responses to science' are regarded as most appropriate to be used.

Using this definition, one can view attitude to science as a way of identifying students' cognitive and emotional opinions about various aspects of life experiences which they have had. Extensive research has been carried out to identify the factors and the effect of certain factors on students' attitudes to science. According to Ato and Wilkinson (1983), students must possess a positive attitude in order to embrace both science-related education and careers. A positive attitude towards science encourages a lifelong interest in the subject (Simpson & Oliver, 1990) whereas, according to Zain *et al.* (2010), a negative attitude towards a given subject leads to a lack of interest in and avoidance of that subject. Fostering positive attitudes will not only help students to develop the necessary traits for studying, appreciating and becoming involved in science-related careers, but also enhance their learning experiences. It prepares people to cope with the continuous development of science and technology, with revolutionary changes in nature and with the practice of the sciences. Certainly, the increase in interest towards particular subjects is not only the most desirable outcome of learning, but is also regarded as an important goal of education (Krapp & Prenzel, 2011). These are some of the main reasons why there has been extensive research done in this area. Positive and negative attitudes towards science in terms of respective variables have been recorded and analysed by the researcher in the current study in order to give a deeper understanding of students' perspectives on science and technology and to establish an evaluation of science education as a whole.

2.2 Issues Emerging

Research on students' attitudes towards science has been conducted on a global scale over the past 30-40 years. Two main stumbling blocks facing research into attitudes towards science have been identified by Osborne *et al.* (2003). The first is that attitudes are formed by multiple subconscious constructs which cause varying proportions of individual attitudes towards science. The second is the measure of the subject's expressed preferences and feelings towards an object. On the same point, Bennett (2003) also compiled a list of issues related to research into attitudes towards science in addition to those of Osborne *et al.* (2003). She added the lack of precision over definitions of key terms, failure to address matters of reliability and validity appropriately, and a lack of appreciation of ethical considerations. The issue of the validity and reliability of research particularly in this area is regarded as crucial due to the lack of standardization of instruments which results in increases in difficulties over constructing and generating conclusions and comparisons between the variety of studies and the isolated nature of the studies done so far.

2.2.1 Measuring attitudes towards science

Attitude is an abstract concept: it cannot be measured directly except by means of words and behaviour (Ramsden, 1998), so a considerable variety of instruments have been developed and used to measure attitude, but their reliability and validity remain problematic (Gardner, 1975; Scibecci, 1984; Ramsden, 1998; Munby, 1990; Bennett, 2003). According to Bennett (2003),

> ... research on attitudes to science is still characterised by a lack of standardisation of instruments, with new studies almost always developing new instruments to collect data. p.181

Kind *et al.* (2007) summarized five main methods of measurement based on the lists of Osborne *et al.* (2003) and Gardner (1975): preference ranking, attitude scales, interest inventories, subject involvement and qualitative methods. Different methods used in the various studies were led by the curiosity of researchers for understanding students’ perceptions and their desire to make recommendations for change, evaluation of the curriculum or new practice in reducing problems (Ramsden, 1998). As stated in the Royal Society’s State of the Nation Report 2007, the main method of data gathering in this area is survey. There are two types of survey: fixed-response items which permits large amounts of data to be gathered but lacks contextualization and interpretation (TRS, 2008), while augmented surveys are labour-intensive but provide an abundance of explanatory data. According to Ramsden (1998), use of a range of data collection methods in a study would provide a means of cross-checking and would increase the validity of the instruments, however, both of these methods depend on the quality of the variable being tested.

Over the years, various tools have been used to measure attitude, but the most popular is using closed or open questionnaires and semantic differential or projective techniques (Schibeci, 1984) on the target variables. Recently, some creative alterations and adaptations have been made in order to have a better understanding of students' attitude, especially to science. This gives better reliability and validity to a study. Bennett and Hogarth (2009), in their study of students' attitudes to school science, came up with a method of measuring attitude among school students which was an adaptation of the Views on Science-Technology-Society (VOSTS) study carried out in Canada in the late 1980s. They came up with an instrument which involved a fixed-response item pool based on views expressed by the students. The developed instrument carefully dealt with the issues of validity by combining the ability of survey to gather large data-sets with the explanatory insights provided by a simple form of pencil-and-paper instrument. This methodology enabled the researchers to gather general patterns of students' opinions.

Koren and Bar's (2009) study in Israel incorporated a closed questionnaire, written essays and semi-structured group interviews based on classic literature and contemporary materials to identify top students' views of science and of 'the scientist'. The study successfully identified the positive and negative views held by students on scientists and on science; furthermore it was able to gather complex explicit explanations of each comment made. More recently, Raved and Assaraf (2011) have used a multiple-case narrative methodology which incorporated the conventional quantitative study with the narrative qualitative (interviews) format in order to understand school science experiences which influence students' attitudes towards science. This technique revealed different angles of students' perspectives and reflected their overall attitude and the factors which affected it (Raved & Assaraf, 2011).

These newer studies have shown the beginning of a new trend in understanding students' attitudes to science by not only identifying the 'problem' by descriptive means, but also being able to 'listen' to the explanation beneath the existing problem by incorporating various explanatory details into it.

Interestingly, attitudes towards science have not only been measured locally but also conducted across nations (Sjoberg & Schreiner, 2005). A collaborative work on The Relevance of Science Education (ROSE) gathered students' perspectives on science in more than 45 countries worldwide. Percentages, means and mode were used to compare the findings and the data were analysed on the basis of the fixed-response and scaling techniques which were used. This descriptive method enabled the researchers to generalize the shared and different attitudes of students across the globe. The continually improving techniques for measuring attitude developed over the years contribute to a better understanding of students' attitudes to objects and of factors affecting their attitudes.

2.2.2 Definition

The lack of a clear definition of some key terms is another issue associated with research into students' attitudes to science (Bennett, 2003; Osborne, 2003; Kind *et al.*, 2007). First, there has been a lack of clarity about what is actually being measured in attitude towards science (Osborne *et al.*, 2003). This issue had been previously raised by Ramsden (1998) who stated that for 'attitude' to be measured there is a need to be clear whether it is attitude towards science in school, outside school, to scientists or to all of these. Lack of clarity and definition will very likely lead to disparate items being tested on an attitude scale (Bennett, 2003; Kind *et al.*, 2007). This in turn will lead to a lack of consistency between the instruments which would make comparison studies impossible (Bennett, 2003). Second, there is a difference between the concepts of 'attitude' and 'interest'. For Krapp and Prenzel (2011), both of these terms create three types of adherent: some researchers believe that they are synonymous (Schreiner & Sjoberg, 2004) while others interpret attitude as a super-ordinate concept within which interest is a specific form of attitude (Osborne *et al.*, 2003). A third group believe that each of these key terms is totally different. It has been distinguished through the evaluation criteria that ‘attitude’ involves non-personal evaluation whereas ‘interest’ involves the subjective value which is attached to knowledge (Gardner, 1998). With the differences in the definitions of some of the key terms, it is extremely difficult to make any comparisons between studies (Bennett, 2001).

Interestingly, with the various types of instrument which have been developed over the years, research in this area has identified a few similar components (Ato & Wilkinson, 1983; Osborne *et al.*, 2003; Barmby *et al.*, 2008). Some studies (Ormerod & Duckworth, 1975; Haladyna & Shaughnessy, 1982; Osborne *et al.*, 2003) have incorporated a variety of components of interest in their measures of attitude towards science which has led to various findings in several interesting areas such as the affecting factors and the impact of attitude towards science.

2.3 Factors Affecting Students’ Attitudes to School Science and Science

Previous work on attitudes towards science indicates that there are many contributing factors that influence students’ attitudes. It has been suggested that student’ attitudes towards science are the result of their response to their experiences and their exposure to science within the school and from outside-school activities (Bennett, 2003), so it is worth differentiating between these two groups of factors which affect their attitudes. Students’ attitudes towards school science are formed by their daily experiences in school based on the syllabus which is determined by guidelines set by the Curriculum Board. According to Reiss (2004), attitudes towards school science are affected by how the content of the curriculum is taught and what access students have to science in school. Although students’ attitudes to science are a result of their exposure to the environment outside school, including the media, government policies, national economic status, culture and the general level of technological know-how, these factors also impinge on school science (Reiss, 2004).

2.3.1 Attitudes towards school science

Teachers, students themselves and their learning environment in school have been identified as the main factors which affect students' attitudes towards school science (Haladyna & Shaughnessy, 1982). From these three factors, teachers were found to be the most important factor in cultivating attitude (Schibeci, 1984; Weinburgh, 1995; Osborne & Collins 2001; TRS, 2008; Barmby *et al.*, 2008). Findings by Osborne and Collins (2001) and Bennett and Hogarth (2009) established that students believed that their science teachers are the ones who are responsible for influencing and determining their response to science. In school, specifically in the classroom, teachers' qualities determine the attitude of the students. Woolnough[b] (1994) established that the quality of teaching of school science is a significant determinant of attitude towards science. In 1991, he identified two prominent factors that were responsible for students' choice of the sciences. The first was the influence of a student's positive experience of extracurricular activities and the second was the quality of the science teaching. This included the teachers being enthusiastic about their subject, setting it in everyday contexts and deliberately conducting their teaching in well-ordered and stimulating science lessons. He also added that students adore teachers who are willing to spend their time in and outside classroom with them, especially talking about science and careers, and mentoring their extra-curricular activities. Teachers with a thorough content knowledge have been found to be capable of delivering effective teaching, identifying errors of fact, correcting misconceptions and making full use of opportunities to elaborate on an issue to help students' understanding (Tobin & Fraser, 1988). This argument explains Sparkes's (1995) findings that more students undertake physics in Scotland because physics teaching is carried out exclusively by qualified physics teachers. With a clear understanding of the subject matter provided by experts in the subject, students possess an enthusiasm for the subject which accordingly increases their interest in science education.

Other factors which have been reported as contributing to attitudes to science in schools include gender, social class and ethnicity (Osborne *et al.*, 2003). Gender has long been a topic of study in this respect. With their different natural characteristics, the different genders are exposed to different environments and different chores. So it is not surprising that gender has long been associated with attitude towards science (TRS, 2008). The lack of girls in science is not new, although awareness of it has markedly increased in recent years. The ‘masculine’ nature of science has been suggested to be the factor that deters girls from enrolling in science courses (Head, 1985). According to Osborne *et al.* (2003), boys have consistently more positive attitudes to school science than girls, especially in physics. Girls have less positive attitudes than the boys regardless of their attainment in the classroom. However, girls’ confidence and level of achievement are increased when they are in single-sex teaching groups in science (Bennett, 2003) but this is not the case for boys. Nevertheless, a longitudinal report from 1996-2007 showed that even attainment in science subjects is not the reason to explain the phenomenon (TRS, 2008). The issue remains unsolved; it might be the result of the masculine image of the scientist, the influence of parents, experiences during childhood, future career plans or perhaps students being self-conscious about their ability. Possibly, it is simply the result of the teachers’ way of conveying information.

The type of school which students attend is another environmental influence which also contributes to students’ attitudes towards school science. Dale (1974), quoted in Bennett (2003), concluded that students gained greater social benefits from mixed schools than from single-sex schools. Boys’ achievement benefited the most compared with that of girls in mixed schools, while girls achieved better in single-sex schools. A study by Jackson (2002) found that girls were more likely to take science subjects and score highly in them in single-sex schools due to their increased confidence.

An OECD report published in 2009 indicated that students' attitudes towards science are related to their performance. The high motivation among the top students is free from socio-economic status but related to enjoyment and active engagement in science learning within and outside school. Enjoyment and interest generated by the intrinsic value of a subject can be regarded as the consequence of the self-perception that one engages in an activity because one likes it, while extrinsic motivation can be regarded as the self-perception that one engages in an activity to obtain environmental reward (Reiss, 1975). There are many strategies for increasing the extrinsic value for students in learning science; some of them involve pedagogy and others extra-curricular activities. Assigning a 'task value' was thought to be a wise solution to contributing to the quality of students' experience and autonomy (Osborne *et al.*, 2003). According to Eccles and Wigfield (1995), 'task value' is the degree to which an individual believes that a particular task is able to fulfil his/her personal needs and goals. It enables students to evaluate challenges according to their abilities. It consist of three components; interest, importance and utility. By being able to satisfy self-needs and potential, students' attitudes to science could be developed and evaluated (Osborne *et al.*, 2003). However, there is no specific guideline given on the best 'task value' practice. Is it best applicable during content delivery or as enriching activities after a formal lesson? Is it meant for all students or only for selected ones? Do different school environments vary the impact? And how do students perceive the activities?

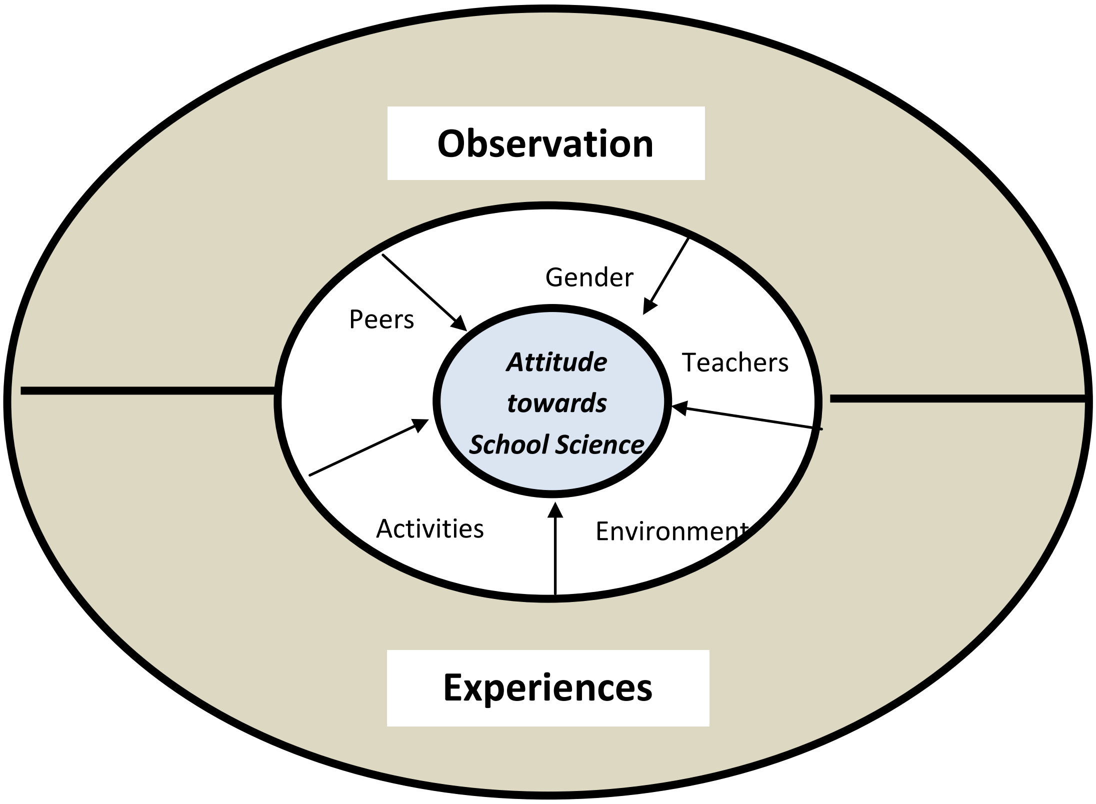

Figure 1: The framework of students' development of attitude towards school science

Figure 1 shows a framework devised from the collected works of previous research into students' attitude towards school science. It is made of two layers of components designed in the form of an 'eye' which uniquely represent the overall idea of learned attitudes.

The outer layer represents the overall source of attitudes. It is divided into two parts, based on students' experience and observation as the result of what they have seen, heard, noticed or observed regardless of their degree of encounter. The familiarity with and reflection upon specific phenomena such as nature, community and national expectations influences attitudes towards school science. Unintentionally, significant attitudes develop and sustain it. Indirectly, attitude development is related to each individual's effort and exposure.

The second layer of the framework groups together all the potential factors which were found in previous research to be the major contributory factors towards attitudes to school science. These are external contributory factors which have a direct impact on students' attitudes towards school science, and comprise teachers, gender, peers, activities participated in and the environmental setting and each of these will be considered separately in the following paragraphs.

i. Teachers

Teachers are the people who are responsible for relaying the main source of first-hand information to students. They are the ones who are initiating the grounds of input in schools and the mediators of content knowledge designed for the students. Relating the content to students' everyday experiences is their major role and is the most influential factor in moulding students' attitude towards science learning.

ii. Gender

Gender has long been associated with behaviour, interest and attitudes. Widely accepted as an important domain in education, gender plays a major role in determining students' attitudes towards school science. Boys are well known to be good in physics and engineering, while girls are proficient in biology and chemistry. However, some recent research studies have proved that gender is no longer to be regarded as the basis for students' level of interest in science but that the teaching approach used is. Which approach is suitable to which gender is still unresolved.

iii. Peers

Students' interaction with their peers is closely related to each student's internal motivation. With the right amount of influences, peers would be able to provide a student with assurance and healthy comparison and would become effective trend setters. As a result, students would be able to identify their own interest and challenge and set their own personal targets. Consequently, peers play an important role in influencing attitudes towards science learning.

iv. Activities

Various activities pose different challenges to participants. With hands-on activities, students have the opportunity to address their fears, test their ability, increase their excitement and confront their frustration which accordingly provides an unforgettable experience for them. These experiences will later determine their interest in and mould their attitudes towards particular areas of study.

v. Environment/ambience

The environment provides stimuli in all sorts of forms and ways. Different stimuli will stimulate the production of different responses and impacts. The school environment can affect and support students' learning experience and motivation. Overall, the environment plays a significant role in determining students' reactions and their attitudes towards science learning.

In summary, students' everyday experiences and observations which are interlinked with these five major factors will develop specific attitudes towards learning science. Initially, unconsciously learned attitudes gradually develop strong attitudes in students towards science learning.

2.3.2 Attitudes towards science

Attitudes towards science in general have not been as well studied as attitudes towards school science. With the differences in life and background, students from each continent and each nation with its own economic status have their own particular perspectives on science. The various circumstances of different nations cause each country to have its own priorities and to put its own emphasis on science according to its economic setting. With their distinct situations and facilities, students in dissimilar areas have diverse exposure to issues and to government ideologies. These factors are collectively reflected in students' attitudes towards science. Based on ROSE studies in more than 40 nations worldwide, students' attitudes vary under different environments and cultural settings (Sjoberg & Schreiner, 2005). Students from the less economically-developed countries appear to have a positive attitude towards science compared with students who come from developed countries. This indicates that young people in these countries find science and technology meaningful. The importance of science to their nation's development is significant. They believe that science and technology are the driving forces for the economic growth, the improvement of health and the public issues of their own nation. In their societies, being involved in science is therefore important and consequently meaningful for their individual achievement. On the other hand, for those countries which are economically well-developed, scientists and engineers are no longer crucial to people's lives and well-being. Being exposed to widespread scientific and technological development, individuals in post-materialistic countries prefer to choose careers which they perceive to be more important than the materialistic agenda. They are more interested in obtaining meaningful jobs according to the needs of their societies, such as careers related to health and environmental issues. Therefore, students in these post-materialistic societies show greater interest in careers in health, environment, democracy and self-actualisation (Schreiner & Sjoberg, 2007). It can be concluded that students' choices of a future career in science are dependent on their perceived values and images of science and technology rather that any lack of knowledge. They prefer to become involved in areas which appear to them to be important and meaningful according to their own ability and interest. Generally, their perspectives on the importance of science depend on the exposure to and experience of science which they encounter every day.

A study by Long and Steinke (1996) suggested that students' perspectives on science and scientists were affected by what they viewed on television. These researchers also added that students' television watching broadened their views on science and scientists which increased their attitudes towards science and maths activities. This informal approach to science is found to be becoming more effective as it influences people's actions, values, thoughts and behaviours (Bandura, 1994). The falsification and verification of observed behaviours or logical thought obviously influences viewers' attitudes, values, motivation and self-capabilities (Long & Steinke, 1996). Therefore, the more people watch television, the better they adapt to the world view. From that study, it was found that students perceived science as fun and as a part of everyday life which is meant for all. This consequently increases their self-efficacy towards science.

All in all, attitudes toward school science specifically can be generally represented as in Figure 1. They are influenced by everyday experience and exposure. As each meaningful experience and observation made by students matters, teachers, the environment and everything in between contribute to the shape of one's attitude towards science regardless of the formality of the situation. In schools, the experiences and exposures may come from various main sources which are teachers, peers, activities, the environment setting and gender. Perhaps identifying which is the best stimulator for each type of student may eventually trigger the appropriate stimulus which will give a significant impulse for them to continue doing science in their future undertakings. With factors affecting students' attitudes towards science identified as significantly varying based on world economic region, gender, age and country, an understanding of this should eventually enable policy makers, educators and governments to construct programmes and syllabuses according to the needs and benefits of the development of their country (Sjoberg & Schreiner, 2005).

The interrelationship between school science and science attitudes is regarded as positive since students show greater interest when teachers associate the science content of the curriculum with their daily experiences. This contextual approach is not only interesting for students, but also an application of Osborne and Collins's (2001) p.3 comment about the need for an "education approach for science" not an "education about science". Science activities in schools should gradually bring students to a genuine science environment, enriching their awareness and bridging the gaps between the theoretical and the practical sides of science in daily life. It is believed that school activities which involve out-of-school experiences can influence students' interest, especially boys (Kahle & Lakes, 1983). This is a pedagogical technique which brings life to the subject and satisfaction to the learner.

2.4 Key Findings

From existing studies on attitudes towards science, there are four themes which emerge as influences on students' attitudes towards science; learning school science, career choices, values held about science and technology, and science's image.

2.4.1 Learning school science

PISA 2006 identified that although students' high attitudes towards science in school are linked with one of the main factors of high achievers (OECD, 2009) unfortunately, not all high achievers have a high interest in science. Osborne *et al.* (2003) reviewed attitudes towards science and identified a number of attributes that affect students' attitudes towards science, and these can be categorised as the attitude of peers (Talton & Simpson 1985; Head, 1985; Breakwell & Beardsell 1992), classroom teachers (Simpson & Oliver 1990; Tobias 1990; Woolnough[b] 1994; Osborne & Collins 2000), curriculum (Simpson *et al.*, 1994; Woolnough[b] 1994) and student's perceptions (Crawley & Black 1992; Hendley *et al.*, 1996; Havard, 1996).

By establishing self-identity and in order to conform to group expectations, the attitude of peers has a strong influence on a student's interest (Head, 1985). Positive values about specific areas are always shared by the members of a group. According to Pine (1999), group settings encourage children to use language, provide explanations to one another and work cooperatively or competitively, all of which help to produce cognitive change. Such collaborative learning, involving a group of students with similar levels of competence, can offer an effective environment for guiding a child through its zone of proximal development (Richard, 2010).

For curriculum materials, not much meaningful information has been gathered on the issue in regard to attitude to science. However, attitudes towards science vary with specific sciences (Whitfield, 1980; Havard, 1996, Osborne & Collins, 2000). Furthermore, an association was made by Woolnough[a] (1994) on the interest shown by boys to the challenge presented by the abstract and mathematical aspects of science, particularly physics, and the desire to explore the subject more in depth, whereas girls value the human and affective aspects of knowledge (Keller, 1985; Harding, 1991; Watts & Bentley, 1993) such as languages, humanities and social studies (Gardner, 1974). A study by Whitfield (1980) suggested that the rejection of science in the 1970s was based on perceptions of the difficulty of the subject, however a study by Osborne and Collins (2000) found that the main reason for the rejection of science was the dullness of learning experiences in the classroom. Many other researchers have been busy trying to identify which style of teaching/learning suits which gender. Research by Bennett *et al.* (2006) established that context-based learning made a significant contribution to science understanding and to students' attitudes to science. The impact of context-based learning is regarded as positive regardless of the gender of the students. It brings excitement, satisfaction and motivation for the students to want to become more involved in science subjects.

All in all, it can be concluded that students' interest in science can be affected principally by the teachers and the knowledge they possess. Hence, with good understanding of content, teachers would be able to explain and teach the subject matter using context teaching which brings life to a subject, particularly in science.

Nevertheless, a review by Osborne *et al.* (2003) concluded that motivation, especially extrinsic motivation, plays a major role in students' interest in learning science (Dweck, 1986; Dweck & Leggett 1988; Paris, 1998; Hidi, 2000). Furthermore, it is a highly significant factor in science classroom achievement. The right motivation involves the freedom to choose, challenge and take control of the pace and the nature of learning and collaboration (Paris, 1998). Consequently, this is in line with Osborne and Collins's (2000) findings, which suggested that students look forward to the opportunities in science for practical work, extended investigation and discussion. In summary, students' engagement in science learning is very much associated with the degree of autonomy they have (Wallace, 1996; Paris, 1998; Osborne & Collins, 2000). The more autonomy they are granted, the more lively the learning experience will be and the more positive they will feel about science. And like achievement, autonomy is strongly related to attitude (Schibeci, 1984). However, no clear association has been made between autonomy, attitude and achievements.

2.4.2 Choosing a career in science and technology

According to the Oxford English Dictionary, a career is "an occupation undertaken for a significant period of a person's life, usually with opportunities for progress", and an aspiration is a "hope or ambition". According to Ginzberg (1966), career aspirations are influenced by two factors; self-determined and environment-determined. Self-determination arises from the students' self-efficacy, values and goals, whereas the environmental influences include working hours, job conditions and qualifications. To Crites (1969), career aspiration is perceived solely in terms of the individual's wants and wishes that are irrespective of the limitations imposed by reality. In order to stimulate students' self-determination, more exposure which is engaging needs to be planned for them. Hands-on activities and self-experience will give adequate exposure to increase their confidence and motivation. According to Colbeck *et al.* (2000),

> "Students are more likely to experience their own accomplishments ... when engaging in active, hands-on learning experiences rather than when passively listening to lectures." (p.176)

Again, there is some interrelationship between students' confidence in their ability and their capability of pursuing a particular career which is made up of their self-achievement, beliefs and exposures. According to PISA (2006) (OECD, 2009), top science performers involved in science-related activities outside schools care more about studying science and making an effort in science subjects. They believe in the importance of science for their future undertakings and career choices. With respect to their aspirations, top-performing students are well prepared for and well informed about science-related careers. In other words, the more exposure they have to direct and indirect experiences, the more influenced they will be towards that subject. This increases their motivation and self-efficacy in that particular area.

2.4.3 Values related to science and technology

> "Whilst science and technology are often seen as interesting to young adolescents, such interest is not reflected in students' engagement with school science that fails to appeal to too many students. Girls, in particular, are less interested in school science and only a minority of girls pursue careers in physical science and engineering." (Osborne & Dillon, 2008 p.15)

Values put on science and technology vary according to a country's continent and level of development. In developed countries, science and technology is viewed as positive and interesting. The acquisition of scientific and technological knowledge in those countries increases over the years. In 2010, Europeans were more interested in science than sport and wanted EU research activity to be boosted (EU, 2010). In that EU report, 80% of Europeans were interested in scientific discoveries and technological developments, 70% thought that funded research will become more important in the future, 57% thought that scientists should communicate more about their research, and 55% agreed that science offered more chances to get a job.

Although they showed high interest in the benefits which science can offer to the development of their country, many had fears about the power and destruction which science knowledge could generate. From ROSE 2004, the challenge faced by the EU was the decline in the willingness to enter into science- and technology-related studies and careers (Sjoberg & Schreiner, 2005).

Views about the future vary with individuals. A personal view of one's future is different from national and global images of the future and of the possibilities which come with it. Views of the future are consequences of personal background and social development. Thus a person's attitude, values and priorities, knowledge and experiences shape his/her image of the personal future (Schreiner & Sjoberg, 2004). According to ROSE, students from developed countries have high regard for science and technology development but less interest in pursuing it. On the other hand, students from developing countries have higher awareness of science and technology and regard it as important for their nation's progress. It seems that there is a close relationship between vision for the future and attitude towards science and technology. Those who are optimistic about the future have a positive attitude towards science and technology in society (Eckersley, 1999). When it comes to environmental problems, the developed countries have a less optimistic view of the future and do not believe that science and technology can solve all the environmental problems. They disagreed over whether it is the responsibility of the rich countries to solve the world's environmental problems (Sjoberg & Schreiner, 2005). This is contradictory to the view of the Asian and African countries, which are more optimistic about the function of science and technology in solving environmental problems (Yoong & Ayob, 2005).

2.4.4 The image of science

The image of science and of the scientist has been a concern to researchers in this field since the 1950s (Etzioni & Nunn, 1974; Hills & Shallis, 1975; Schibeci & Sorensen, 1983; Bennett, 2009). Students' perceptions on both issues have been evaluated by paper-and-pencil procedures such as using Likert-scale questionnaires and semantic differential instruments (Schibeci & Sorensen, 1983). The method of the ‘Draw-A-Scientist Test (DAST), invented and used by Chambers (1983), found that 4807 students across Australia, Canada and the United States had a stereotyped image of scientists; they were bearded males, wearing glasses and coats, engaging in typical laboratory work, producing products (technology) and symbols of knowledge which included books and filing cabinets. From that study, it emerged that the image of a scientist becomes more intense with the student’s grade. This image is not only a well-known figure seen in the students’ minds but has also been portrayed in exactly the same way by cartoonists and even amongst scientists themselves (Schibeci & Sorensen, 1983).

That study has been continually replicated by many researchers around the globe, but there has been no discussion about what role these images play in students’ attitudes towards science. Koren and Bar (2009) set out to identify the positive and negative images of science and scientists held by 125 high-school children in Israel. A variety of images emerged. The positive images were; the cognitive abilities of the scientist (high level of intelligence and wisdom), scientists feel responsible towards society’s needs, and they are committed and responsible towards their scientific endeavour. On the other hand, some of the responses showed a more ambivalent image. Some children believed that scientists are:

a. intelligent, but there is the stigma of ‘mad’ and ‘un-social’ in them;
b. capable of bringing both benefit and damage to society;
c. materialistic and reward-dependent;
d. people of impressive personality which functions in a poisonous manner;
e. able to benefit society but have anti-social behaviour; and
f. able to advance technology but cause social harm

(Koren & Bar, 2009).

With these interpretations of their images of scientists, the students had various reasons to want to be or not to be involved in science and to be a scientist. However, the study did not discuss the role which these images play towards science. Does the notion of someone working alone in a secret room, with a secret mission and an untended physical appearance, affect their perception of science and of scientists? Does invention appear to be something difficult which requires many personal sacrifices? Or, perhaps, working long hours alone in excluded places causes girls' interest to shy away from science and scientists?

In 1996, an interesting study on awareness of science values, especially on self-efficacy, was carried out on students' views about public images of scientists in television programmes. Long and Steinke (1996) used televised images to provide an opportunity for students to observe the actions, attitudes and thoughts of scientists. The image of science as fun and as part of everyday life, and the image of science as something for everyone were far more apparent that the image of science as magical and mysterious. It was apparent that actors portraying scientists influenced the students' self-efficacy toward scientific activities and motivated them to participate in science-related activities, such as conducting experiments, reading science books and visiting museums.

A study conducted by Bennett and Hogarth (2009) found that the image of the scientist did not alter much among UK high-school students. Most of the students questioned admitted that they would trust something that a scientist said, that they would like to have a science-related job, and that science outside school is not a bad thing, but even so, the majority view was that science was "not for me" (Jenkins & Nelson, 2005).

Perhaps being involved in a science field and working with real scientists would help to patch the torn images and perceptions towards science and scientists. According to Long and Steinke (1996), direct involvement in environmental events will stimulate behaviour directly because it will provide information about learning and will influence students' decisions about their future behaviour. In this case, it eventually helps to give a better contextual understanding to those who have the potential for and are capable of doing science.

There appear to be four emerging impacts of attitude towards science (*see* Figure 2). Most of the research has tested the impact of students' attitudes towards science in the values of science and technology, learning school science, careers in science and technology, and the image of science. The impact of attitude towards science has a strong effect in determining the future of the nation in terms of science and technology. Previous research has elaborated on how particular stimuli cause reactions towards the development of attitudes and the resulting behaviour which is correlated to attitudes. Figure 2 shows a summary of the four impacts of attitude towards science which emerged from the literature reviews, and factors affecting it.

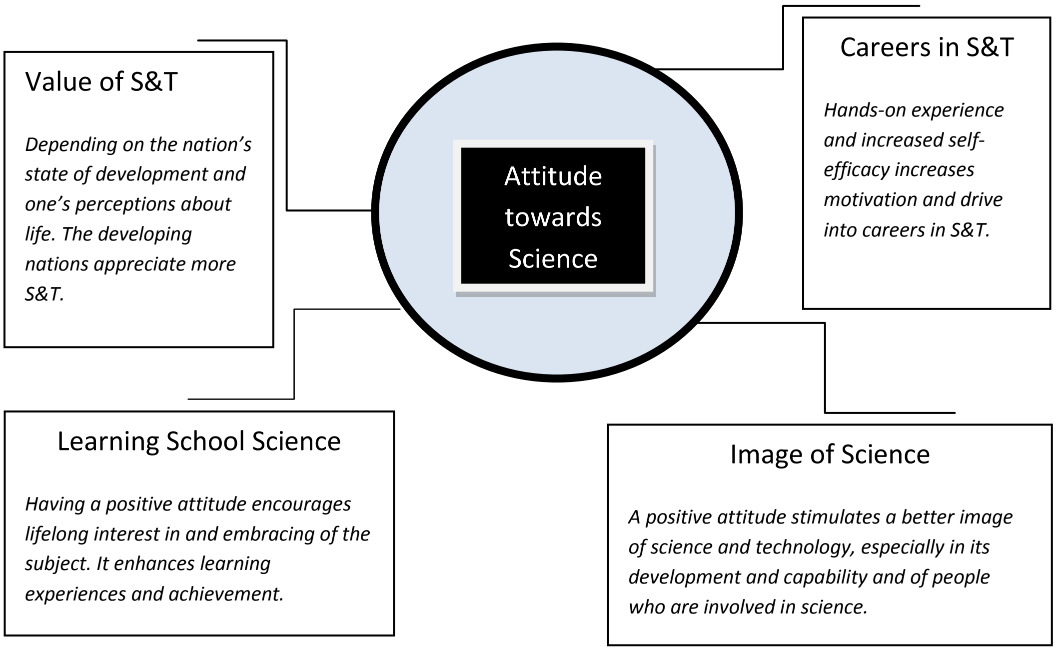

Figure 2: The impact of attitude towards science on students' science learning development

Attitude towards science plays a major role in altering students' science learning development. Various studies have pointed out its impact in determining the students' value of and possible careers in science and technology, their learning of school science and their image of science. By having positive attitudes towards science, students are found to show more appreciation of scientific developments, nature issues and global interests, particularly creating a sustainable environment, pollution, global warming and human interventions. With this increased interest, students can develop their image of the future. An individual's image of the future is the most significant determinant of his or her personal behaviour (Polak, 1961). Consequently, in this case, it determines students' eagerness for experience, enthusiasm for learning and willingness to pursue the science field in their future life. Their curiosity and determination are shown through their interest in learning science in and outside the school compound.

A positive attitude stimulates a better image of science and technology. Scientists, engineers, astronomers, gastronomists, naturalists and environmentalists are some in a long list of people who are being looked up to by students and are associated directly with the image of science. The positive or negative images of such people in the science field indirectly influences a student's future career pathway just as much as his/her personal interest. Thus, students' feedback on their choice of careers is essential as it acts as a significant indicator of their future undertakings.

The Relevance of Science Education (ROSE) survey was developed in 2004 to assist the understanding of the parallel impact of students' beliefs on science and technology and the future of society. It was a collaborative effort of science education expertise in collecting information from young people worldwide in order to contribute to, to inform and to provide critical reflection about the current challenges, as well as to collect and analyse empirical evidence that sheds light on attitudes towards science issues (Schreiner & Sjoberg, 2004).

The ROSE questionnaire was designed to examine six areas which can be categorised into three main areas; first, desired science education curricula, students' opinions on science and technology, and students' experiences outside the school classroom. The second component comprises 'my future job', 'me and my environment', and 'my science classroom and my opinions about science and technology'. The third part of the questionnaire gathers students' experiences outside the classroom. The students' experiences outside the classroom provide information on their interests and on their exposure to all aspects of activities which are relevant to science and technology. Even though it can be classified into three parts, part two and part three are significantly interrelated and support each other especially in informing students' attitudes towards science. Therefore, the questionnaire in this current study used items in categories two and three to explore the students' attitudes towards science.

ROSE does not access directly the four impacts as simplistically as shown in Figure 2. However, of the 76 items in the second category, 55.3% of the items are related to the students' attitudes towards science and concentrate on the four impacts as illustrated in Figure 2. There were eighteen items which investigated the students' value of science, five items asking about their perceptions of following careers in science and technology, fourteen items gathering their opinions on learning school science and five questions on the image of science. Even though this does not reflect exactly the four attributes shown in Figure 2, 55.3% of the material from the total questionnaire is accepted as significantly sufficient and it has been repeatedly used by more than 50 nations, therefore the reliability and validity of the items are unquestionably useful to this study. Therefore, this study used the second and third parts of the overall questionnaire to understand the residential students' attitudes towards science. It was administered to all six schools in order to explore their attitudes for comparison with the national survey undertaken in 2004. This enables a fair assessment of the internal evaluation and overall valuation of the residential school students' attitudes towards science. Therefore, using the items in this way permits evaluation and justification of specific issues related to the value which students put on science and technology, to their school learning experiences, to their thoughts on careers in science and technology and to the image they hold of scientists and of science.

2.5 The implications of the study

Responses towards science are vital indicators enabling us to foresee the future of a nation's scientific development. Encouraging students into science provides much benefit in preparing them for a scientific and technological way of life. It helps them in decision making and it increases the size of a trained work-force and a science-literate community. Accordingly, one of the popular ways which has been used for years in cultivating students' interest in and motivation towards science is organising science competitions amongst them. However, it remains unclear what the impact of science competitions is on students' responses towards science.

In addressing the existing literature on attitudes to science and to school science in particular, the method used in each study is the most crucial element. This is because of the intrinsic complexity of 'attitudes'. A measurement must inculcate the three elements of 'attitudes'; affective, behavioural and cognitive. Furthermore, the definition of attitude needs to be precise and any instrument used must have proven reliability and validity in order to allow a better understanding and acceptance of the existing body of knowledge. This current study has therefore carefully integrated three types of strategy in order to understand the impact of science research based competitions on students' responses to school science and science in general.

The study used the existing Relevance of Science Education (ROSE) questionnaire, with some alteration in regard to the main objective being to understand students' responses to science. This is a well-known questionnaire which has been used throughout the world, including Malaysia, and the version used in this study was designed to give an overall picture of the status of higher-achieving students' responses to science in comparison with previous Malaysian data and with data from the rest of the world generally. The instrument was intended to gather students' perceptions and their emotional and attitudinal views (Schreiner & Sjoberg, 2004). There is no need to argue the validity and reliability of the instrument as it has been used and tested worldwide. The questionnaire was specifically designed to be used in order to give a well-based overall picture of high-achievers' responses in Malaysia towards school science and to science in general.

The questionnaire used a four-point Likert scale from 'Not interested' (value 1) to 'Very interested' (value 4). This psychometric response scale was primarily used to obtain the participants' preferences or degree of agreement with a statement. It is a non-comparative scaling technique and is uni-dimensional in nature. In some cases scales such as this may generate: a central tendency bias where participants may avoid extreme response categories; an acquiescence bias which participants may agree with statements as presented in order to please the experimenter; or, a social desirability bias which portray themselves in a more socially favourable light rather than being honest. On the other hand, Likert scales do allow associated multi-item scales and summated rating scores (Schreiner & Sjoberg, 2004). Therefore, the scale was used due to its potential to provide a highly reliable scale which is easy to read and complete by participants.

With no intention of generalization, the study was carried out in a series of case studies in order to understand the impact of science research based competitions on the contestants. Therefore, to enable the researcher to make a sound conclusion about the programme, the questionnaire was designed to be accompanied by two further complementary explanatory research methods, interviews and students' diaries. By using these additional methods, it was hoped to clarify the development of attitudes and positive responses to science which emerged amongst the contestants. The interviews were designed to gather information on the students' cognitive reaction to their experiences and to the lessons learned during the competitions. In addition, the students' diaries were used to explain students' feelings and behaviour during the stressful period of preparing for the competitions. The evaluation of the programme is not only based on the collected individual views on the programme but also includes the views of the teachers in charge, of policy makers and of competition organisers. By this means, it was hoped to increase the reliability and validity of the search topic as the use of three instruments was intended to give an effective triangulation to the data acquired in the study and to permit an in-depth understanding of the subject. The definition of attitudes is made clear at the very beginning and it specifically focuses on students' attitudes towards school science which includes learning science at school, career development, out-of-school science and the image of science as a whole and of scientists. Whereas the definition of responses includes the definition of attitudes with the addition of extra skills, which in this case is science processing skills.

An evaluation of the impact of science competitions on students' responses to science is significantly important as competitions play an active role in school science learning and involve a serious collaboration of agencies and institutions. Money, time and effort invested in the programme need to be justified and assessed for whether it is all worth the effort or not. The responses of students to school science and to science in general which emerge from the programme will help the policy makers and organisers in evaluating the significance of the programme for the benefit of Malaysian national development towards 2020.

Chapter 3: Science Competitions

Overview

According to the Oxford English Dictionary, a competition is an event or contest in which people compete (Thompson, 1996). Competitions are considered to be popular and valuable tools in the educational process. There are many types of competition available in every area and at various levels (Bellipanni & Lily, 1999). They are low-cost mechanisms to uncover exceptional talent (Campbell *et al*., 2000) and incorporate sets of challenges, rules, monitoring, judging and awards. Accordingly, new talent will be elicited through competitions, and competence in dealing with challenges in specific areas can be generated. In general terms, competition is part of the human survival challenge. It involves all aspects of life, from the very basic needs as stated in Maslow's hierarchy of social needs, which range from a striving for recognition and acceptance by others (Anthony, 2009) to self-actualisation. In the context of this particular study, there are various types of competition in science education and they have been held as part of the education system for decades. They come in several formats, levels of difficulty and target participants. In particular, this research focuses on high-school students' attitudes towards science during and after their involvement in science research based competitions. A science research based competition is defined as a type of science competition which involves non-academic, out-of-classroom activities on science projects, and is also known as a science fair. The primary component of a science project typically includes an investigation, report writing, and verbal and non-verbal presentation on a particular research area (Balas, 1998).

3.1 The History of Science Competitions

Science competitions are also widely known as science fairs, and involve science projects (Abernathy & Vineyard, 2001; Bellipanni & Lily, 1999; Czerniak, 1996). Their origin has been traced to the USA in 1928 (Bellipanni & Lily, 1999) and to Russia in 1934 (Kukushkin, 1996). There are two types of competition, academic and non-academic (Campbell *et al*., 2000). The Russians claim to have been the first to identify the potential of academic competitions and initiated the academic Olympics. The first academic Olympic programme involved Mathematics and was held in Leningrad in 1934 (Kukushkin, 1996). These competitions spread all over the USSR and were used to funnel talent into specific areas tailored to the national needs, specifically those of military and science services. The outstanding participants were granted automatic admission to some of the best universities in the country (Campbell *et al*., 2000). This admission process supplied a steady pool of talented individuals in the science and engineering spheres in Russia. This early segregation of talents is believed to have been what ignited a pool of exceptionally talented scientists in Russia and indirectly contributed to the launch of the first Sputnik in 1957 (Bellipanni, 1994). Subsequently, there have been twelve more types of science Olympiad competition around the world, including the International Mathematics Olympiad started in 1959, the International Physics Olympiad in 1967, the International Chemistry Olympiad in 1968, the International Astronomy Olympiad in 1996, the Biology Olympiad in 1990 and the Junior Science Olympiad in 2004 (International Science Olympiad, 2011; Campbell *et al.*, 2000). According to Oliver and Venville (2011), “the International Science Olympiads are annual competitions supported by UNESCO for gifted school students in a number of science subject including biology, chemistry and physics”. They involve intensive examinations on theoretical and practical science lasting up to five or six hours. These types of competition put great emphasis on the understanding of the specific subject and the significance of the wide range of its content area in everyday life. They are primarily based on voluntary group work involving four to six participants (Abernathy & Vineyard, 2001).

On the other hand, non-academic competitions featuring topics such as innovation and engineering were initiated in 1941 in the US (Feist, 2006; Bradwein, 1951; Zim, 1941). These were initiated as a science exhibition in 1939, then developed into Young Talent Search in 1942 and finally merged into the International Science Engineering Fair (ISEF) in 1998 (Terzian, 2008). Since 1950, the US ‘Science Fair’ has provided a means of identifying students who are interested and talented in science. This was an after-effect of the first Sputnik launch on 4 October 1957 by the USSR (Campbell *et al*., 2000). Edwin Teller, the science advisor to the then President Eisenhower of the US, was responsible for persuading the government of the need to start a non-academic contest and to target young Americans to get them actively involved in technical areas at an early age. At that time, the US was in competition with the USSR not only on space exploration but more importantly to prove overall superiority in every field (Wirt, 2011). The US government believed that by having science competitions, a mechanism to uncover exceptional talent could be generated at little cost and that this pool of talent would become a valuable asset for the nation. The practice still continues, but with larger scales of participation and better-structured assessment mechanisms.

In order to develop extraordinary talent, competitions are mostly funded by governments and supported by foundations and companies (Campbell *et al.*, 2000) such as Intel, Toyota and NASA. This represents a social obligation to respond to the initial needs of the national expectation of developing talent and to supply the need for a technical workforce and a pool of expert workers. Eventually, this workforce will determine the national economic health and development. These collaborative efforts signify a mutual understanding over the nation’s future undertakings between the government sectors and independent agencies. In the US, the Westinghouse Corporation sponsored the largest, most selective and most prestigious science talent search for high school seniors from 1942 until 1997 (Feist, 2006). From 1998, the role has been taken by the Intel Corporation, which continues to be the main corporate sponsor of the biggest international science and engineering fair which is well-known today as the Intel ISEF. According to Terzian (2008) p.1, “the corporate sponsorship of the high school science extra curriculum at the World's Fair marked a turning point when the progressive purposes of science education began to give way to 'manpower' and 'professionalist' ends that aligned with the nation's economic and military imperatives".

Recently, this kind of extra-curricular science activity has attracted high interest among science communities, school and educational boards, policy makers and non-government agencies all over the world. They successfully incorporate various science disciplines such as engineering, mathematics, biochemistry, genetics, robotics and many others into a project. All these competitions involve a high demand for research in different areas of science, primarily designed to develop students' interest, motivation for science learning, and science reasoning in order to build new content knowledge (Strauss, 2001; Bellipanni, 1994). At the same time, the competitions were also regarded as a platform for students who show potential but are unsure of their capabilities in science (McBurney, 1978) and for those who want to challenge their endurance by committing themselves to something new and challenging.

There is a wide range of difficulties and levels in such competitions (*see* Figure 3). They integrate a great amount of subject content into the same pot. Some of it involves high-end research over a long period of time and uses multiple subject disciplines to develop new applicable knowledge, devices or findings. However, there is some which involve simpler tasks over shorter periods of preparation time and specifically focus on a particular area. Various kinds of competition have been designed according to the different ages and capabilities of the targeted participant group. Some examples are the The Rio Tinto Big Science Competition, the Eureka Schools Price, the Murder Under the Microscope, the Exploravision Awards, the Future City Competition, the Water Rocket Competition, the Solar Car and the Cooking With Nature, the International Science Poetry Competition, the International Robotics Olympiad and the Big Bang.

From a collected data-base (*see* Appendix A), the non-academic competitions can be divided into two different areas. The first is a competition which involves various multi-discipline areas with very little research and a short period of preparation. This type of non-academic competition will be referred to hereafter as 'non research based science competitions'. Examples are science quizzes, science poetry, science theatre and discovery science. The second category of competitions comprises those which involve a high level of science knowledge with long hours of research and which engage participants in specific scientific skills and procedures; this type of non-academic science competitions will be referred to hereafter as 'science research based competitions' (SRBC). Some of the best-known SRBCs in the world are the Intel ISEF, Science Fairs, F1 *inschools*, the World Robotics Olympiad, the Toyota Youth Challenge and the Dr Nelson Ying Science Competition. The differences between the two categories are based on the level of research involved, the level of science acquisition and the time allocation.

With the classification that has been described above, the differences between the various competitions are clearer, which means that better judgement and evaluation of science competitions has become possible and feasible. First and foremost, this allows the researcher to refer to a specific category, which is hopefully beneficial in making it possible to point out the differences between them, as science competitions come in various formats, levels of difficulty and target participators. Clarifying the various types will enable the researcher to identify the differences and similarities and to predict the outcome of particular studies.

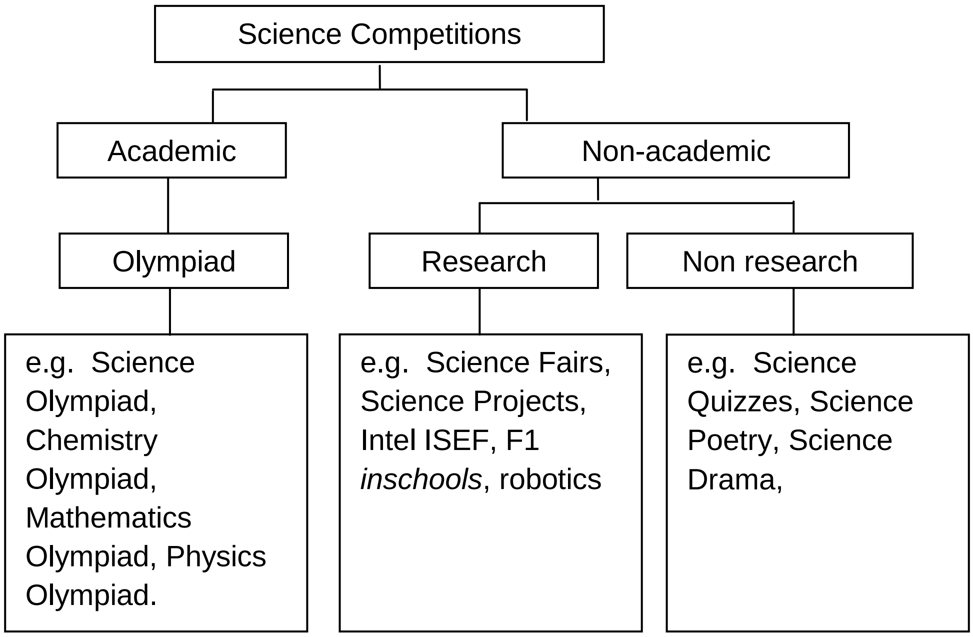

Figure 3: The types of science competition which emerge from the literature

Competitions which involve lower levels of research are mainly designed for lower attaining students. They are designed into various types of competition such as poetry, quizzes and role-play and also are conducted at many levels. However, this involves explicit scientific content with less application of multi-content knowledge, needs fewer days of preparation and requires minimum contact hours with teachers or mentors. As this does not involve much actual scientific research activity, it does not require students to be engaged in specific scientific skills and procedures. It calls for students to be good at elaborating specific subject or content knowledge in particular areas.

Generally, competitions which involve higher levels of research are mainly designed for the more talented students (Campbell *et al*., 2000). They are designed uniquely into various themes and conducted at many levels such as between schools, cities and regions/states and at national fairs. The winner of a national fair will be selected to compete in the international arena. This competitive screening results in a very prestigious and challenging experience for the participants. Consequently, over the years, the programme is claimed to be beneficial in inducing the sprouting of exceptional talent amongst the students who take part (Bellipanni & Lily, 1999).

The first national science fair, which involved high-school students in the US, was held in 1950 in Philadelphia, Pennsylvania (Bellipanni, 1994). This first national fair involved thirty finalists whose exhibits were the best from thirteen local and regional science fairs (Science News Letter, 1950). Eventually, after national fairs had been held for twelve years, an international science fair was then launched in 1962 in the US, and involved 387 finalists, included two participants from Japan (Science News Letter, 1962). The International Science Engineering Fair (ISEF) then followed in 1964 in Seattle, in Washington State (Bellipanni, 1994). It was a platform for demonstrating science research projects from 208 finalists from around the US and seventeen finalists from other countries (Brown *et al.*, 1986). The popularity of the science fair spread as time went by. In 2009, there were over 1500 young scientists from fifty countries all over the world competing for the USD 4 million scholarships and prizes offered (Intel, 2010). With longitudinal data collected on previous finalists and award winners, it is agreed that the ISEF has played an important role in the past forty years in fostering the development of science and mathematics education in science (Bellipanni, 1994).

In Europe, the Federal Republic of Germany has an elaborate mechanism for conducting competitions to suit all levels of ability. There are more than twenty federal (nationwide) competitions and dozens of smaller competitions at state or regional level. These involve over 100,000 students nationwide annually. They participate either as individuals or in groups on various science disciplines such as mathematics, biology, chemistry, physics, technology, computer science, environmental studies and others. Most of the competitions are subsidized by the government with a total allocation of €4 million in 1999 (Campbell *et al*., 2000). The major focus for sponsoring competitions in Europe is based on the belief that they will activate and strengthen the interest of young people in the subject matter and thus improve their knowledge and ability. While struggling with the challenge of a competition, students enhance their abilities of working autonomously, they release their energies and they enhance their perseverance.

In Malaysia, national science competitions started in 2000. There are collaborative efforts between the Ministry of Education and a number of independent agencies in order to select the best Malaysian representative to compete in international events. There are about twenty different science competitions and science research based competitions monitored each year by a science desk officer in the Ministry of Education. Millions of ringgit are allocated annually to sponsor and organize various competitions at different levels in Malaysia. Most of the participants who have been sent to international events have been winners in regional competitions and have successfully gone through the challenges and requirements set by the specific international guidelines.

In spite of being a newcomer in this competitive arena, Malaysia has come up with numbers of competitive teams each year. The effort from the Ministry, from school administrators, teachers, students and the non-government sector shows that Malaysia is trying hard to be in line with other developed nations in science competencies, to be recognized and at the same time to cultivate interest amongst the potential scientists in the country, as stated in the aims of Vision 2020. Since participation in these competitions started in Malaysia, there has been no study, no evidence or no record of programme monitoring or of students' development in the science field. In Malaysia, the main task has been to provide and to gain exposure for the students, for their mentors and for ministry officials to the world standard of the projects. Winning is ultimately important as it brings immediate recognition of the quality and scope of Malaysia's schools system to the world and its product in the making (Sasbadi, 2009; F1 *inschools*, 2006.

3.2 The Aim of Science Research Based Competitions

In recent years, researchers have gradually worked on identifying and understanding the types, advantages and issues of having competitions for a number of reasons. According to Campbell *et al*. (2000), there are several rationales for conducting competitions; identifying children with talent at an early stage, providing an option for schools to develop the talents of extraordinary students, attracting talented students to participate, motivating early talent development and developing it intentionally, and encouraging talents which will be a benefit for the positive growth of the society as a whole.

The diversity of science competitions provides us a long list of objectives according to the designated area of interests (*see* Appendix A). However, the main aims of science research competitions are principally focused on a few common key words; to recognise and promote science appreciation, to stimulate interest, and to provide and develop skills. These provide the most frequent statements used in science competitions;

i. To recognise
   – remarkable talent early on, completed science projects and the scientist's contribution to and involvement in science research and work.

ii. To promote
   – the understanding and appreciation of science and its role;
   – the value and the importance of science to business, students and the community;
   – science as an attractive career for students;
   – the direct involvement of students in the process of science.

iii. To stimulate
   – science learning in the form of hands-on/minds-on;

– interest in science, technology, engineering and mathematics amongst young people.

iv. To provide

– a platform for like-minded students to exchange their knowledge, networks and skills;

– opportunities for them to expand their horizons in the areas in which they are most talented and which they like most.

v. To develop skills:

– higher-order thinking skills;

– problem solving skills;

– scientific skills; and

– communication skills, especially in reporting and delivering scientific findings.

These key verbs used in determining the aims of the competitions conducted show that science research based competitions are tailored to be an alternative platform for students to get themselves involved directly in science, technology and engineering. They were designed for high-capability students who have a high interest in science. This enriching and enhancing programme acts like a booster to the education system. However, from the list of aims given above, none of them are measureable, indicating that no direct data via observation can be collected on the success of the programme. The only indicator which has been used has been based on the students' responses and achievement after completing their formal educational studies. The first question raised is, 'Why do we need to stimulate those who are already capable and have a passion for science?' and then, 'Would it be any different if the competitions were redesigned for those who have potential, but not in science, technology and engineering?' and 'What are the benefits of doing this type of competition over more than sixty years?'

3.3 The Effects of Science Research Based Competitions

Over the sixty years of the history of science research based competitions, several researchers (Abernathy & Vineyard, 2001; Campbell *et al.*, 2000; Bellipanni & Lily, 1999; Schneider *et al.*, 1996) have amassed a number of studies of the competitions. These views collectively can be grouped into the effect which competitions have had on students in segregating talented students, in culturing research skills, in building interest towards science and research and in future career choices. Most of the views have been taken mainly from the general perspective of science competitions which are in the format of a science fair. Despite the fact that science competitions are considered to be one of the most popular activities, there are still areas which are under-researched. This is because most of the studies on science research based competitions were carried out after researchers had been granted permission to included data on the ISEF participants in 1993 (Bellipanni, 1994). This area has been taken for granted as a consequence of its long presence in the educational system. Therefore, there are obvious limitations on some research areas such as students' responses to science, the expectations of the sponsoring agencies on the programme, the students' expectations and teachers' role in mentoring the project.

3.3.1 Segregating students' talents

According to Campbell *et al.*, in 2000, science competitions were regarded as feasible to be conducted in schools due to the small cost they require. It can be added that they are easy to administer and organize; they can be made accessible to a broad number of participants and they can be designed accordingly to suit any level of ability (Campbell *et al*., 2000). Science competitions did serve as a reliable filter and were useful for constructing interest and motivation above the normal syllabus, especially in the early years when schools were unequipped with specific programmes for identifying and educating the brighter and more-talented students. This type of activity was considered to be a mechanism to uncover exceptional talent, and to elicit, stimulate and challenge talent in many different fields (Campbell *et al*., 2000). However, the imbalanced entry due to gender-skewed interest in certain science areas led to the uneven distribution of the search for talent. As a result, issues of unfairness in the other gender rights were raised, and, for example, one study has significantly identified that there have been more girls participating in science fairs than boys; the situation has been reversed, however, for the Olympiads (Abernathy & Vineyard, 2001). According to that study, this was probably due to the nature of the competitions themselves. Boys are attracted to participate in an Olympiad because it involves team work and involves volunteer students; whereas, on the other hand, the girls are keener on science fairs because they are more focused on individual participation. However, the association still remains unclear because of the insufficient data that has been collected.

Although none of the previous studies support the claim of 'filtering talent', it seems not impossible to spot the talented students in such highly prestigious competitions which involve high levels of science research and demand full commitment from participants. However, with the emergence of many tests for talent and for identifying interests in the current education system, the role of SRBCs as an agent of segregation for the educational system to allow talented students to be trained into specific channels is yet to be investigated. This raises a number of questions. Does the current education system recognise and benefit the talent which is filtered out and does it create a follow-up on it? Does doing science research still fit the purpose of segregating talent or is it merely a continuation of the science activities in the education system? Furthermore, are competitions unfair, as only limited numbers of students can be segregated at one time and most of the participants in competitions are students who are already labelled as the best crop of the system.

3.3.2 The value added skills

High-end research competitions and academic-based competitions are mainly designed for students who are in grades 9-11 (15-17 years) and those who want to venture into something extra with no academic strings attached (McBurney, 1978; Smith, 1985). The competitions provide a platform where students are able to show their ‘sciencing’ in subjects into which they have conducted an active investigation (McBurney, 1978). It has been said that in science fairs, students should be able to conceive and plan a project, perform an investigation and analyse data to arrive at some conclusions or understanding (Smith, 1980). They offer an opportunity for students to go beyond the planned science curriculum to pursue individual interests and talents. Consequently, they open up the opportunity for examining practical problems using hands-on/minds-on activities that link science with other facets of the curriculum (Balas, 1998).

Carrying out experimental science projects requires the students to practise the science processing skills which they have been taught in class. Therefore, the more realistic the problems they identify, the more exciting the solution and the greater the adventure they will experience along the way (McBurney, 1978). In view of that, participation allows students to further develop their science content knowledge, processing skills and science interests (Mann, 1984; Grote, 1995). Eventually, if the students successfully follow appropriate scientific methods while investigating and experimenting, it will help them in understanding related science concepts (Bellipanni & Lily, 1999). This is closely aligned to the primary objectives of science projects, which are to teach students to think (Tant, 1992), and to help them to organize and to make decisions on important information gathered (Recht & Leslie, 1988; as stated in Bruning *et al*., 1995). They provide students with another learning platform on topics of their personal interest, letting them demonstrate both factual knowledge in written reports and procedural knowledge through the research process (Bruning *et al*., 1995). Furthermore, they enable students to generate, analyse and assess the impact of the findings, as well as to connect what they have learned to experiences beyond their science project (Balas, 1998).

According to Grote (1995), science projects teach students about scientific methods and promote their interest in science. A longitudinal study by Oslon in 1985 indicated that participation in science fairs should encourage others as it benefits the interested students by providing them with the opportunity to travel, increasing their poise, self-confidence and communication skills, earning them respect from their peers and developing their research and experimental design skills (Olson, 1985). Unfortunately, that study did not elaborate on the specific experimental skills observed. McBurney (1978) commented that making students' participation in science fairs compulsory is equal to forcing them into the use of intellectual skills that may not have yet been properly developed. With their determination to win and impress the judges, students have undertaken new outstanding projects which are often beyond school levels in order to compete in the fairs. Quite often, students' projects reflect the work of their parents or their parents' friends rather than the work of the students themselves (Grobman, 1993). A study by Abernathy and Vineyard (2001) noted that students' motivation was driven by the urge to please their teachers' expectations rather than by other factors.

Reviews of the achievement of the programmes from the point of view of the organisers, especially the Ministry of Education and the programme co-sponsors, have not been gathered in any of the existing research. Because these people are responsible for running the competitions, understanding their motives, achievements, views and hopes is essential. This is due to their social role in the community and the realisation of the national aspiration.

Currently, the existing literature has concentrated mostly on the after-competition impact on the participants. This covers the students'/ participants' opinions on various areas such as awards, motivations and satisfaction with the programmes. Data have also been gathered from teachers on their students' performance during the competitions and on the overall programme, and on their thoughts regarding the impact of the programmes on students' scientific skills. Then again, there are several areas that are still under-researched; students' perspectives on the challenges which they encountered before and during the competitions, their satisfaction with the overall programme, the skills and knowledge which they developed in certain areas, the lessons learned by participation, their passion for science and its effect to attitudes to science (Figure 2). Their views are important in evaluating the success and the potential for improvement of the competitions. In summary, greater understanding as outlined above will give broad-brush information on science research based competitions in respect of students' responses to science.

The main reasons for organising the competitions need to be addressed and revised in order to evaluate the effectiveness and success rate, especially in the context of the development of education. Agencies which support the programme need to be addressed and acknowledged. Effort put up by the mentors (teachers) is significant in influencing the success of projects made each year. These factors would give primary information on the significance of the events to students in general. Therefore, their views on the competitions and on the behaviour changes which the competitions require are essential. This knowledge will contribute to maximising the success of the programme in the future.

A study by Schneider *et al*. in 1996 collected teachers' views on their perspectives of their students' science projects. They were asked questions based on seven educational goals for science education: exploration of a real-world issue, hands-on/minds-on, scientific knowledge, higher-order thinking, habits of mind, integration and social skills. From their findings, the researchers suggested that a science project is an important part of science education. It is regarded to be an effective way of addressing the new educational goals for science, of incorporating hands-on/minds-on science with the goal of scientific knowledge, and it allows students to use scientific inquiry and higher-order thinking skills through the exploration of real-world issues (Schneider *et* al., 1996). That study concluded that students' science projects are complementary to their science learning experience.

In 1985, Campbell summarised the skills developed by the winners of Intel Talent Search in the US as attitudes and orientations, time management, research (library) skills, scientific and advance reading, organization skills especially in managing a project in a given time-frame, and discipline in conducting scholarly research studies. According to Campbell, by mastering these skills, participants not only relish a challenge but will also benefit in their future undertakings. It is therefore true to say that there are no 'losers' in competitions of this type as everyone will gain additional skills simply by participating (Campbell *et al*. (2000). Evaluations of the skills gained have been made in various ways. For example, Parker and Gerber (2002) devised a performance-based assessment to evaluate the knowledge and skills of a group of students during their participation in a science projects competition. In the study, the students' projects were ranked as 'outstanding' and 'high quality' for each individual and for the group category. Unfortunately, this result cannot be generalized because of the limited size of the sample.

There are recurring issues with the competitions, especially with the judging (Abernathy *et* al., 2001; Grote, 1995; Grobman, 1993; Cerlisle & Deeder, 1989). Studies by Grote (1995) found that 53% of the respondents believed that science fair judges should be trained or professionally qualified. Poor-quality judging will definitely produce bias and unfair results and will have a negative effect on the participants and also on the science institution. Judges' perspectives on the projects, and students' science attainment and attitudes towards science, have yet to be gathered in order to fine-tune both the expectation and the actual achievement acquired by the participants.

Nevertheless, all the current studies in this area have merely been collected in the form of general opinions from parents and teachers without being supported by measured data and findings, especially on the skills developed. More measurement of the claims needs to be carried out in order to assess the types of skill developed in the types of competition organised.

Bearing in mind these identified gaps in the previous research, this current study was designed in a way which will incorporate the three main sources of data (participants, mentors and organisers) from fully identified backgrounds on various aspects of the competitions at the beginning of, during and after the competitions. This will allow a better understanding of SRBCs and the potential and the diversity of the challenges encountered, particularly by incorporating the hands-on/minds-on experience to students' attitudes towards science as mapped in Figure 2.

3.3.3 Interest in science and research

With hands-on experience of a particular project, students have the freedom to explore, experiment with and observe previously unknown phenomena by themselves. Eventually, this exploration will help them to organize the information gathered and allow them to make decisions on the importance of information to their topic (Recht & Leslie, 1988; Balas, 1988; Schneider *et* al., 1996). It will provide students with another avenue of learning more about topics of personal interest to them, it will enable them to generate, analyse and assess the impact of their findings, and it will connect what they learn to experiences beyond the science project (Bruning *et al.*, 1995).

According to Balas (1998), science fair projects help students to become more responsible and purposeful and they foster the development of a student's awareness of his/her personal capabilities and qualities. They also help students by developing their appreciation of the natural world and their understanding of the relevance of science in daily life experiences, thus promoting positive attitudes towards science. Studies by Bellipanni (2001) to rank participation in SRBCs identified that the students have a positive attitude towards science, regarding it as fun and enjoying learning new things, and Wilson *et al.* (2004) agreed on how SRBCs increase positive attitudes towards science among the participants.

On the concept of learning, competitions provide experience of a constructivist framework in which students build on their prior knowledge by accumulating new information and material which is researched by reading, observation and experimenting. Collaborative interaction with peers, mentors, parents and their teacher also adds to their experience (Vygotsky, 1979 as cited in Bruning *et al*., 1995). According to Vygotsky's theory of the 'zone of proximal development', this interaction between novice and expert can bring the novice to a higher level of accomplishment than the novice could expect to reach on his/her own. This will eventually increase the level of students' self esteem and their belief in their ability to learn science. Similarly, Bandura (1986) suggested that learning is influenced by three components; the personal beliefs of the learners, their behaviours, and the environment. In sum, by participating in science competitions, students have opportunities to reflect on and make total sense of their overall educational experience (American Association for the Advancement of Science, 1993). A study conducted amongst teachers in 1995 concluded that science fairs promote interest in and enthusiasm about science, provide the opportunity for students to learn about the research behind their friends' projects, and open up an opportunity for academic discussion with an outside observer (the judge), which enhances their interest in research (Grote M., 1995). Indirectly, this acts as an acknowledgement of their effort and scientific skills.

3.3.4 Future career choice

Czerniak (1996) reported that involvement in science fairs is one of the best ways to develop the skills, attitudes and knowledge that will lead to a successful career in the future. The increase in positive attitudes among students hopefully increases their confidence in choosing science as their future career. This corresponds to earlier papers by Huler (1991) and Marsa (1993), which showed that students who entered the Westinghouse Talent Search frequently pursued careers in science and became the best in their fields. A study by Olson (1985) pointed out that 73.5% of the participants in the North Dakota Science and Engineering Fairs from 1951-1985 believed that the science fair had had some influence on their career choice, with 51% of the sample selecting science professions. Of these, 47% gravitated towards biological, agricultural and health, 47% chose engineering and applied science, while the remaining 6% took physical science and mathematics-related careers. Campbell *et al.* studied the achievement of 229 Olympians using longitudinal studies in 2000 and found that 110 (51%) of the Olympians went on to obtain a science doctoral degree and 76% of them reported that the programme helped to increase their awareness of educational opportunities.

Even so, there has been very little information gathered on the progress of the participants after the competitions, especially on their career choices. Indirectly, it can be assumed that the competitions are largely successful in inducing students' interest in science and research, and therefore it can be hoped that this can be nurtured gradually with time.

3.4 Issues associated with Science Research Based Competitions

There have been some issues raised regarding the practice of science research based competitions. In a study of the perception of science fairs, Watson (2003) found that the students were not only learning pure science or content, but also learning the difficult skill of articulating the sequence of steps which has already been referred to: gathering information, conducting experiments and presenting the findings. In addition, the parents perceived that the teachers were mainly concentrating on ensuring that the students organized their thoughts and understood the science processes involved in the competitions, and were not sure whether their children learned anything except the step-by step organizational skills. They believed that their children would learn more by writing papers, as this made their children look at things more closely as they grew older. With the experiences gained, the participants developed their step-by-step organizational skills and gained confidence for undertaking such assignments (Watson, 2003).

There have been few discussions about the reliability of previous studies, particularly since most of the articles written about the effectiveness of science fairs have been based on opinion rather than research (Carlisle *et al*., 1989; Grote, 1995; Czerniak, 1996; Schreider *et al*., 1996; Abernathy *et al*., 2001). Furthermore, a report by NSTA (1986) asserted that students participating in the competitions should do so on a voluntary basis and that emphasis should be put more on learning experiences than on awards. The report also stated that most research studies had been based on higher-level science fairs such as regional, state and international fairs, in which high-achieving, competitive and successful students participate, who already possess science aptitude and a positive attitude. Thus, the existing research does not contribute much to the understanding of the true potential of science research based competitions in terms of students' development. Moreover, the backgrounds of the participants have not been stated clearly in the available studies. Also, Anderson (1996) commented that science fairs have not always been successful in promoting the goals attributed to the students.

Collectively, most of the existing studies on students' interest in school science and research have examined only the opinions of a second party (teachers). This bears little resemblance to the experiences of those who are participating, of mentors, of judges or of the organisers. This creates an unfortunate gap in the understanding of the overall impact of the activities.

Chapter 4: The Methodology

Overview

This study focuses on the impact of participating in science research-based competitions on students' responses towards science. This chapter elaborates on the interviews held with the key informants followed by a series of case studies in six residential schools. The study was based on a summative evaluation (Bhola, 1990) of four stages. The first stage involved gathering the intentions of policy makers from the Ministry of Education and sponsors from independent organizations in organising, conducting and contributing to competitive events for students. Interviews with these key informants permitted a deeper understanding of their aspirations, of the role of the competitions and of the magnitude of their contributions.

After the first stage was completed, six case studies were conducted in various residential schools in the centre of Malaysia. This second stage involved identifying and measuring the responses to science of sixteen-year-old Malaysian higher achievers. The findings gathered from responses to a questionnaire were used to compare scores with data previously collected nationwide in 2004 and as a bench-mark to the residential students' attitudes to science. The information on responses which emerged was useful in highlighting the higher achievers' responses to science. Deep study of the details and specific data revealed important categories, dimensions and interrelationships between the items which were questioned. This stage also involved studying the effect of two specific factors on students' responses towards science; participation in science research-based competitions and the type of school which the students were attending. The findings were used to single out the most prominent factor which contributed to the students' interest in science.

The third stage involved gaining a deeper understanding of the impact of science research-based competitions on students' responses towards science. The aim in this stage was to articulate the participants' views on the effects of their participation on their responses to science, to the challenges encountered and to the lessons learned. This was done by analysing their five-week students' diaries and then conducting in-depth interviews. The final stage of the study involved interviews with the participating teachers. The aim was to gather their personal views of their students' responses towards science, both in regard to their role in mentoring the projects and in managing the students' research.

As a result, this study articulates an holistic view of science research based competitions from the viewpoints of three types of informant; the organisers (policy makers and independent organisers), the participants and the teachers in charge. All this contributed to a greater overall understanding of the impact of science research based competitions on students' responses to science and the attainment of objectives.

4.1 Data Collection

Data collection was designed according to the aims described above, and involved a multiple-case study approach. Case study has been explained in different ways by various scholars; according to Patton (1990), case study acts as an attempt to evaluate individualized client outcomes. For Bryman (2008), case study entails the detailed and intensive analysis of a single case. Berg (2007) and Yin (2003) both defined case study as "an approach capable of examining a simple or complex phenomenon, with units of analysis varying from single individuals to large; it entails using a variety of lines of action in its data-gathering segments, and can meaningfully make use of and contribute to the application of theory".

Case studies have been chosen as a research design in various studies for many reasons (Yin, 2003). It has been found to be a design that is capable of generating particularly useful information based on specific cases (Patton, 1990). It has also been found to be a valuable method of capturing individual or unique variations from one programme setting to another. Berg (2007) claimed that case study produces extremely rich, detailed and in-depth information. Collectively, this type of evaluation has proven to be successful in combining qualitative and quantitative data, secondary and primary data, interviews and observations (Patton, 1990; Yin, 2003; Bryman, 2008).

Multiple-case study or collective case studies are often used in research studies. They are applicable when a researcher is combining a few case studies in a study; the method is also known as cross-case studies and comparative case studies (Merriam, 2001; Berg, 2007). It involves extensive study of several instrumental cases; it allows better insight and makes it possible to theorize about a broader context. It is found to give better understanding of a subject than the single case method (Thomas, 2010) and appears to be more compelling and robust (Yin, 2003).

Despite the benefits, however, case studies are often limited in the extent to which their findings can be generalised. What they gain in internal validity they lose in external validity. According to Bryman (2008), this is caused because “the evidence they present is limited due to restricted external validity and unable to generalise to other cases or to the populations beyond the case” p. 57. Nevertheless Bell (2005) has commented that generalization of the findings is not a major issue, especially when the findings are more relatable and can make it possible to generate theory out of the findings (Yin, 2003; Patton, 1990; Mitchell, 1983). Another disadvantage of case studies is that the researcher relies too heavily on interpretation in guiding the findings and recommendations. This is also known as the self-fulfilling prophecy or the Pygmalion effect.

Taking all these points into account, this study has incorporated a variety of data collecting strategies: interviews, student diaries and questionnaires from three important sources; the organisers (the policy makers and the independent organisers), the students and the mentors. Their different perspectives were gathered and triangulated. This produced an individualized outcome and therefore minimised the bias effect. The research methodology was designed as a multiple-case study of six residential schools from the three types available. The combination of the six case studies provides an in-depth understanding of the particular area which is still being researched and offers relatability to its targeted subjects. Relatability is an important factor offering adequate in-depth details to enable understanding for someone who is working in a similar situation (Bassey, 1981). Furthermore, the strategies used support the objectives and the problem at which the research is aimed.

This multi-case study employed mixed-method data collection techniques; a qualitative study was carried out with sets of key informants followed by a quantitative survey conducted to determine the responses to science as well as the qualitative insights of those participating in science research based competitions. The data collection gave emphasis to both methods, with qualitative methods leading to quantitative (Morse, 2003). The combination of these methods can be considered a mixed-method study (De Cuir, 2008; Bryman, 2008). It generates a robust and sound understanding of the subject studied.

Mixed-method study is noted for its capacity to allow a mix of two different methods, which results in a better understanding, and a better balance between the strengths and weaknesses of a study (De Cuir, 2008). Combining different research methods can provide a more comprehensive view of the risk issues which are inevitable in a single methodology (Poortinga *et al.*, 2004). It is also provide a complementarity to various aspects of wider phenomena investigated (Gorard & Taylor, 2004). According to Ercikan *et al.* (2006), quantitative and qualitative research can be viewed as complementary rather than mutually exclusive and as a continuum rather than polar opposites. “It may provide a better understanding of a phenomenon than if just one method had been used” (Bryman, 2008) p. 608. Particularly for this study, the chosen method accomplished the five purposes stated by Greene *et al.* (1989: 259, cited in De Cuir, 2008);

i. Triangulation – it uses both quantitative and qualitative approaches to show convergence of the study. The data for triangulation applied in the study were collected by different approaches; questionnaire, interviews and students' diaries.

ii. Complementarity – it examines the intersection of different aspects of a phenomenon. The study incorporates the aspirations of the policy makers and the sponsors with the reality of current students' attitudes towards science and students' and teachers' views on the programme.

iii. Development – with one method informing the development of the other. The aspiration gathered from the organizers and sponsors determined the questions asked during the participants' interviews and confirmed by the teachers' input.

iv. Initiation – to discover as well as explore contradictions found when using the method to explore the same phenomenon. Students' views on the impact of participation in competitions were examined through questionnaires and the findings led to the exploration of their five-week diaries and were finally confirmed by the in-depth interviews.

v. Expansion – the multiple approaches extended the breadth and range of the study. The impacts of the programme were determined through the questionnaire, interviews and students' diaries from the viewpoint of the three different types of informant.

Data were collected in four stages; in August 2009 and between March and June 2010 in Malaysia, as shown by the timeline in Figure 4.

The first stage was carried out in August 2009 in Malaysia. This phase was divided into two parts; the interviews with the key informants on science research-based competitions, and pilot interviews with participants in the competitions and with teachers in charge. Four key informants were identified and interviewed. The first was the key person from the Ministry who was responsible for coordinating and supervising science competitions nationwide. His views revealed the Ministry's aspirations and capabilities in coordinating the competitions. The other three were from the independent organisations which were actively involved in organising and sponsoring science competitions among secondary school children in Malaysia. They were sponsoring competitions in innovation and engineering, in motor racing and in robotics. The interviews with these key persons enabled the study to gather insight into their aspirations and the types of sponsorship involved.

A month before the interviews, each of the key informants was given by email a set of semi-structured interview questions (*see* Appendix B) on their involvement. The interviews were then held in their respective offices in Bahasa Malaysia; each interview lasted from 45 to 60 minutes. However, they were allowed to answer in English, in Bahasa Malaysia or in a mix of both. They were asked for their permission for their interviews to be recorded, and all four of them agreed to this. When they were completed, all the recorded interviews were transcribed and, when necessary, translated into English. To ensure that they were comfortable about revealing their thoughts and problems, their interviews were treated confidentially and anonymously.

	Date	Research Activities	Stages
2009	**May**	Finalised research questions and instruments.	
	June	Contact schools.	
	July		
	August	***Pilot semi-structured questionnaire to students and teachers involved in SRBC.***	(Stage 1) (Pilot interviews)
	September	***Conduct interviews with key informants.***	
	October	Transcribe interviews.	
	November	Analyse and report on collected data.	
	December	Reconstruct instruments and finalise the methods.	
2010	**January**	Contact EPU, schools and teachers and obtain ethical consent from university.	
	February	Finalise the instruments, study time-line and contacts.	
	March	***Distribute questionnaires to selected students in selected schools.***	(Stage 2)
	April	***Start five weeks of students' diary keeping.***	(Stage 3)
	May	***Science competitions.***	
	June	***Interview participants and teachers.***	(Stages 3&4)
	July	Analyse questionnaire responses.	
	August	Report the findings.	
	September	Transcribe interview sheets.	
	October	Analyse the gathered information.	
	November		
	December		
2011	**January**	Report and thesis writing.	
	February		
	.		
	.		
	.		
	December		

Figure 4: The study timeline in relations with the research activities and stages

4.1.1 Sampling Strategy

Taking finance, time and accessibility into account, a mix of deliberate selection and convenience sampling (Patton, 1990) was carried out. The second part of the study was carried out using a multiple-case study on the three types of fully-residential schools in the centre of Malaysia. There are fifteen residential schools scattered throughout the central region (Selangor, N. Sembilan and Putrajaya) from a total of 58 residential schools in Malaysia. There are divided into two different types, co-educational schools and single-sex schools. As different types of school generate different types of culture and atmosphere, the sample for this study was selected according to the type available. For sampling purposes, two co-educational schools, two boys schools and two girls schools who were all practising Form 1 intake and offering pure science subjects to students in Form 4 and Form 5 were picked at random. Bearing in mind that the real study was planned to be done in March 2011, choosing schools which practised Form 1 intake was regarded as a practical decision as it would supply samples of students who would have been in the residential system for at least three constitutive years, compared with schools practising Form 4 intake. The logic here was that the longer the students were immersed in the system, the more residential school programmes and activities they would have participated in. This would therefore contribute to the reliability of the study in terms of generalising the results to the residential school system in Malaysia.

So there were now eight schools that matched the research requirements in terms of type, intake and subject offered; two girls residential schools, two boys residential schools and four co-educational residential schools. So a final selection of two out of the four co-educational schools was made. The selection of schools this time was based on the number of years they had been in operation and the schools' overall performances. This decision was made to match the reputations of the other four schools already selected. In sum, six of fifteen schools, which represented 40% of the residential schools in the centre part of Malaysia (*see* Table 1), were chosen to participate in the study.

Table 1: Distribution of Residential Schools in Putrajaya, Selangor and N. Sembilan, Malaysia

Type of school	Form 1 Intake		Form 4 Intake		Total	
	Science Stream	Science & Religious	Science Stream	Science & Religious	Science Stream	Science & Religious
All Boys	2	-	1	-	3	-
All Girls	2	-		-	2	-
Co-educational	4	6	-		4	6
Total	8	6	1	-	9	6

Adapted from (http://bpsbpsk.webs.com/senaraisbp.htm) retrieved on 23 February 2010

The second stage involved a stratified sampling of 360 students from the six selected schools within the centre region. The students selected were those who had been in the residential school system since Form 1 and were currently in Form 4, who had an odd series registration number, and who were currently taking a pure science course. The reason for this choice was that the longer the students had been in the system, the more exposure to and adaptations of the system they would have had, whereas new Form 4 students would only have been immersed in the system for two months. The reason for using an odd sequence number of registration was to provide adequate random sampling among the population, and the criterion of taking science classes was imposed to ensure equality of exposure and experience received.

The selected students were required to answer a questionnaire comprising a set of questions structured in a Likert scale format. Data gathered from the survey were coded and analysed for quantitative interpretation. Along with the primary data, secondary resources in the form of raw data, published resources and literature on previous Malaysian students' attitudes towards science revealed in the nationwide survey carried out in 2004 were also employed. A comparison of the findings was carried out and similarities and differences were identified. Unique attributes of high achievers' attitudes towards science were therefore highlighted.

The third stage of the study comprised an in-depth consideration of at least two participants in each school (either in the innovation or the engineering category). The selected students were selected at random by their mentors based on their project. The selected students were asked to record their thoughts in a diary and were interviewed after the competitions. Before the students were asked to begin their five-week diaries, they were briefed by the researcher on how to record their feelings and experiences effectively. The five-week time frame was purposely set in response to the findings from the pilot interviews. Students' feedback during the pilot interviews showed that the last five weeks before a competition are the most productive period for them in accomplishing their research and finalising their preparations. Therefore, this is the best time to gather as much detail as possible on how the participants deal with their stress and with the development of their projects. They were asked to record challenges encountered during a particular week, how they solved them, their comments, their reflections and their plans for the following week. The information which was collected gave an insight into the changes which they made and the endurance which they required throughout the critical period. To ensure that they were comfortable about revealing their thoughts and problems, their diary entries were treated confidentially and anonymously, and were handed in to their mentors in a sealed envelope. The envelopes were then collected by the researcher on the competition day.

An in-depth interview followed two weeks after the competition. The interviews were carried out using criterion-purposive sampling with the same set of students. This provided an opportunity to draw together their deeper thoughts and overall experiences of the programme. They were asked for their permission for their interviews to be recorded, and all of them agreed to this. Standardised open-ended interviews were carried out with the participants in groups (a maximum of three participants in each group). Initially, the interviews had been arranged to be carried out individually. However, considering the students' time constraints and administrative approval, groups of a maximum of three students were found to be the most manageable and convenient alternative. This was an efficient strategy as it enabled the researcher to gather the views of two to three students within an hour. It also provided a conducive, friendly atmosphere for the participants and at the same time gave a manageable recording, voice recognition and transcribing experience for the researcher. Despite the use of group sessions, the transcription of the interviews was based on their individual perceptions of the overall programme, the experiences, the benefits, the career plans and the problems which each student had faced. This was done in order to capture as much as possible unique opinions from their various individual experiences. The interview recordings were transcribed individually and analysed accordingly. To ensure that they were comfortable about revealing their thoughts and problems, their interviews were treated confidentially and anonymously.

The fourth stage involved a set of teachers from the schools. Selected mentors were chosen randomly by each school's Principal according to their involvement in current projects. Teachers' personal views on their role in mentoring and managing the project, and their perceptions of the impacts of SRBCs on their students were gathered in separate interview sessions. Their views were used to verify and to act as an additional input to those of their sixteen-year-old protégés. Their interviews were also treated confidentially and anonymously.

4.1.2 Achieved Sample

The final sample therefore consisted of six schools which were fully representative of all-boys schools, all-girls schools and co-educational schools in the central part of Malaysia. The achieved sample included 186 girls and 174 boys, yielding an overall sample size of 360 (*see* Table 2). The numbers of successful submitted diaries and interviews are listed in Tables 3 and 4 respectively.

Table 2: Distribution of respondents on attitudes towards science questionnaire to types of residential schools

Type of school	Number of Schools	Number of Respondents	Percentage (%)
All Boys	2	125	34.6
All Girls	2	117	32.3
Co-educational	2	120	33.2
Total		360	100

Table 3: Number of diary-keeping respondents to types of residential schools

Type of school	Expected	Received
All Boys	4	1
All Girls	4	4
Co-educational	4	4
Total	12	9

Table 4: Number of interviewees according to experiences to types of school

Type of School	Participants		Mentor
	Experienced	Inexperience	
All Boys	1	2	2
All Girls	3	-	1
Co-educational	1	3	2
Total	5	5	5

4.1.3 Logistics and Practicalities

Approvals were obtained and appointments made for the first phase of the research by correspondence directly with the targeted individuals by telephone, email and formal letters. Their ability and readiness to respond greatly facilitated the studies which were used by the researcher to pilot the study.

For the second part of the study, permission to enter schools and carry out research in Malaysia was granted by the Economic Planning Unit in the Malaysian Prime Minister's Department in March 2010. An application was submitted following all the requirements and specifications as stated for undertaking research in Malaysia in General Circular No 3, 1999 (EPU, 2010). Notifications to selected schools and to the Malaysian Ministry of Education were made a month in advance. Confirmation and tentative permission for the study followed two weeks before the visit (*see* Appendix C). Once permission was granted, the researcher had the ability to carry out the study within the year from March 2010 to March 2011 and was granted official consent to have access to any documents and sources required for the study.

Suitable dates, venues and times were then set according to the availability of the teachers and students. Before each interview, the interviewee was asked to sign an agreement to allow the use of information given to the study. Participants were involved in four months of the study (from March until June 2010), which included the three main phases of the study; pre-competition, competition and post-competition.

4.2 The Questionnaire

The questionnaire used for measuring students' attitudes towards science was adapted from the Relevance of Science Education (ROSE) project. See Section 4.3.1 for more details of the ROSE project. The questionnaire was compiled using 137 relevant Likert-scale questions from the 245 original questions. The 108 unused questions were in the section asking 'What I want to learn about'. In ROSE, this section aims to match the curriculum to the students' needs. The section was therefore omitted from the present study because it is less significant in terms of understanding the students' attitudes towards science . This left five areas of questions: students' future interest in science; their attitudes towards environmental issues; their perceptions of school science classes and their motivation for learning science in school; the role and function of science and technology (S&T); and students' experiences of S&T outside the science classroom.

To maintain the students' concentration, and the reliability and validity of their responses, the 137 questions were divided into two different sets according to arrangements of different sections and were distributed randomly between the students. The purpose of this was to give an equal distribution and higher response success probability to the questionnaire. The questionnaires were distributed in the selected schools and monitored by the respective teachers appointed by the school Principals. Since the ROSE questionnaire is not considered to be a test, there is no correct answer to each statement asked, so no strict administrative guidelines were applied. The most important thing was the ability of the students to understand the statements, respond honestly and produce reliable data within an adequate time frame. In proportion with the data collected nationwide in 2004 (Yoong, 2005) when students were given 70 minutes to answer around 250 questions (including the student background questions), the students in the present study were advised that they had been allocated a 45-minute time frame to complete their responses. This was more than sufficient for all the students to read, understand and give appropriate responses to the statements asked.

4.2.1 ROSE Background

ROSE is an international cross-cultural comparative project on young peoples' views and perceptions, attitudes, values and interests, plans and priorities in relation to science and technology (Schreiner & Sjoberg, 2004). It was devised by Svein Sjoberg and Camilia Schreiner from the Department of Education in the University of Oslo, with major financial support from the Research Council of Norway and with the involvement of international science educators who participated actively in the international symposia organised by the International Organisation for Science and Technology Education (IOSTE); the project has snowballed into a large research entity involving over forty countries (Malaysian Research Report Summary, 2005). The questionnaire is targeted at students towards the end of secondary school (aged 15+), who are in the final year of compulsory education in most countries, and often at the age when important educational or career choices are made. This particular instrument is designed and used worldwide to describe the S&T-related experiences that students have, the kinds of interests they have in S&T-related contents, and what views and attitudes they have towards S&T in society. It also captures students' views on their school science experiences, their plans for their future undertakings in their careers or their continuing education, and their perceptions on the current issues involved in environmental challenges.

The questionnaire is made up of 245 items divided into six parts: 'What I want to learn about', 'My future job', 'Me and the environment, 'My science classes', 'My opinions about science and technology' and 'My out of school experiences'. Internationally, the questionnaire is administered over about two teaching periods (1 hour 10 minutes). Four levels of Likert scale are used varying from *Disagree* to *Agree* and sometimes from *Not interested* to *Very interested* or from *Not important* to *Very important*. The usual *Neutral* response is omitted in order to commit the students to putting their responses along the scale continuum and not simply avoid responding. The collected input is then coded and analysed using SPSS.

In the current study, the coded responses were analysed by carrying out factor analysis in order to classify the items into common underlying denominations or factor clusters. These would allow the summarising of the responses and data reduction. For the Malaysian data, factor analyses were carried out using the Principal Component method followed by varimax rotation with Kaiser Normalization. Only factors with eigen values greater than 1.00 were extracted (Yoong, 2005). For each factor cluster, descriptive statistics (mean and standard deviations) were derived for each item. The mean scores of individual items instead of the aggregated mean score for each factor cluster were reported. Coded as a 4-point scale in the data analysis, the resulting scale intervals will be used to interpret the mean scale value of each item for each group of respondents. The *interested – not interested*, *agree – disagree*, and *important – not important* divide was set at 2.50 on a scale that ranged from 1.00 (low level of interest) to 4.00 (high level of interest).

4.2.2 Rationale

The use of the questionnaire was because of its known validity and reliability in gathering students' responses to science. Each item put forward in the questionnaire was relevant to the study and designed to give reliable feedback on the students' responses to science. Furthermore the questionnaire was a valid resource for comparing the immediate residential schools students' responses with the responses of the general population towards science in Malaysia. It provides the same ground of comparison amongst the Malaysian populations and residential students responses to science. The new findings allow a balanced discussion of both populations and therefore permit evaluation and justification of particular issues. The findings from the study give an insight into the residential students responses to science. It is crucial to understand the level of their responses as they bear the national aspiration to becoming a well-developed country by 2020. However, some adaptations were made to the basic questionnaire to ensure that it fitted well with this research study.

Alterations to the original questionnaire were made in a few parts; the set of items used, the cluster arrangement, the format of questioning and the time allocation, and additional information was included relating to activities linked to science research based competitions. As explained above, only five out of the original six ROSE sets of items were chosen for the current study. This was because of the irrelevance of the first section, ‘What I want to learn about’. The section aimed to match the curriculum to the students’ needs, so it was not required for the current study. Because of the omission of immaterial items, the number of items was reduced from 245 to 137. This consequently led to a reduction in the time allocation for completing the questionnaire from an hour and ten minutes to only 45 minutes. To maintain the students’ interest, energy and truthfulness, the items were rearranged into two different sets. The different sets were distributed randomly to ensure the validity of the responses.

The original title of the section ‘My out of school experiences’ was deliberately changed into ‘My out of science classroom experience’. This change was made in order to minimize the potential misunderstanding among the residential students of the phrase ‘My out of school experiences’. In its original form, this statement might lead them to believe that it referred either to experiences they had encountered at home which only happen during the school holidays or to experiences outside the science classroom, or perhaps to both. This ambiguity would eventually lead to uncontrollable responses and misleading information about the residential school system. Additional items were added to the demographic data, namely the school’s name, individual involvement in SRBC, types of involvement and experiences of winning. This information was needed in order to identify the effects of type of school and participation in SRBCs on their responses to science.

4.2.3 The Instrument and Rationale

The questionnaire was adapted from the ROSE questionnaire administered in Malaysia in 2004. Parts of the explanation were based on the text in the ROSE handbook (Schreiner & Sjoberg, 2004) that was made available to each participant’s country. The adapted questionnaire is shown in Appendix D.

It is rather lengthy questionnaire with 137 statements. To avoid respondent fatigue while answering, the statements were divided into several sections and arranged in two different sets: Set 1 (A, B, C, D, E) and Set 2 (D, C, E, A, B). The contents are summarised next.

4.2.3.1 Demographic Data

The first part of the questionnaire contained five questions which were used to segregate the students into gender, age, type of school, participation in science research-based competitions and level of achievement. The gender and age items were included in the original questionnaire in 2004, thus a comparison could be made between the related data when necessary. Type of school, participation and levels of achievement in science-based competitions were three new items inserted in order to find the relationship between the responding variables. These are the traits that were used for identifying the contributory factors which influence students' responses to science in residential schools.

Students' interests in and responses to science have often been linked to gender. So this item was chosen to be one of the backgrounds of the study and was meant to understand whether it is pertinent in schools which practise equal potential entry. Social interaction and school climate are also linked in contributing to the learning environment for students. Therefore, the question on type of school was used in order to identify the existing relationship between the type of school in regards to students' attitudes to science.

The details of the questionnaire used are shown in Appendix D.

4.2.4 Analysis of the quantitative data

The coded responses were processed using SPSS and followed precisely the common guideline for data entry stated in the Malaysian Research Report, 2005 and the ROSE code book (2002). The reason for this was to ensure a comparable set of data to the nationwide findings in 2004. The raw data were cleaned and run according to each of the research questions. Exploratory factor analyses were carried out in order to seek for patterns in the answers to the surveyed items. This will classify the items and detect any structure in the relationships between the items, that is, it will cluster items into common underlying dimensions. Consequently, it will determine the extent to which each dimension is explained by the contents of the items within it. In this way, a summarisation of the data can be generated and named accordingly to connectivity of the items in the same group.

Factor analyses were carried out using the Principal Component method and then followed by varimax rotation with Kaiser Normalization. Following exactly Malaysia's study in 2005, only factors with eigen values greater than 1.00 were extracted. The underlining statistical assumptions of factor analysis, that is, the Kaiser-Meyer-Oikin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity, were also tested.

Separate factor analyses across gender, type of school and participation in SRBCs were initially performed, and the factor structures for those categories were found to be essentially similar, suggesting that the underlying factor structures derived from the factor analysis of the combined residential schools sample would be meaningful and homogenous.

In each factor cluster, descriptive statistics (mean and standard deviations) were derived for each item. The mean scores of individual items instead of the aggregated mean scores for each factor cluster were reported. Coded as a 4-point scale in the data analysis, the following scale intervals were used to interpret the mean scale value of each item for each group of respondents. The *interested – not interested*, *agree – disagree*, and *important – not important* divide was set at 2.50 on a scale that ranged from 1.00 (low level of interest) to 4.00 (high level of interest). However, the bi-polar responses were evaluated by referring to the frequencies of each item, which indicates a clearer weight in the students' responses.

Table 5: The value of the responses codes used in the questionnaire

Value	1.00 to 1.75	1.76 to 2.50	2.51 to 3.25	3.26 to 4.00
	Low interest level	Not interested	Interested	High interested level
	Strongly disagree	Disagree	Agree	Strongly agree
	Not important at all	Not so important	Important	Very important

One-way ANOVA test statistics were also performed to assess differences in gender, type of school and participation.

4.3 The Interviews and Students' Diaries

The study gathered data from the key informants – students and teachers – using a variety of techniques. In-depth interviews were used to gather information from both students and teachers. The students' diaries, however, were used specifically to seek information only on the students' feelings and experiences during the period of preparation for a competition.

The study focuses on four main impacts; the readiness of students to take up science challenges, their interest in science phenomena, the students' points of view towards S&T development, and their interest in a continuing science career in their future undertakings. Views from the various sources were assimilated to support the aim of the study.

4.3.1 Interviews

Interviews have been interpreted as a conversation with a purpose (Berg, 2007). Specifically, the purpose of interviewing is to gather information from targeted subjects (Patton, 1990; Bryman, 2008). Interviewing is a powerful tool in understanding un-observable items such as feelings, thoughts and intentions. According to Patton (1990), qualitative interviewing started with an assumption that the perspective of others is “meaningful, knowable and able to make explicit”.

There are various types of interview which are designed for various reasons. This study employed standardised open-ended interviews (Patton, 1990). It used the exact wording and sequence of questions which had been determined beforehand. All interviewees were asked the same basic questions in about the same order. The questions were worded in a completely open-ended format. The strength of this approach is in enabling respondents to answer exactly the same questions, thus increasing the comparability of the responses and ensuring that data are complete for each person asked in a limited period of time. This reduces the risk of interviewer effects and permits evaluation of the instruments used in the process of assessment. It helps to facilitate the organisation and analysis of the data. Even so, this technique reduces flexibility, and does not allow the researcher to pursue topics which were not anticipated when the interview questions were written. There is also the constraint of using the same lines of questioning with people who have different types and levels of experience.

To minimize the weakness of the flexibility due to using standardised wording during interviewing and limiting the naturalness of the responses, triangulation of data collection was exercised. For the participants, keeping a diary will provide supporting information on the views gathered in the interviews. Supporting printed documents were also used to strengthen the key informants’ views, and students’ perspectives were used to inform the teachers’ interviews.

The interview questions were piloted during the first stage of the study. This enabled the researcher to collect responses and include related issues into the main study. All the issues which were gathered from the pilot interviews were based on reactions to the last question; ‘Is there anything else you want to say?’ Additional information and elaboration were collected in the main study by using the same technique. This technique therefore permitted greater understanding of the overall picture.

In order to understand the impact of the programme from three difference perspectives, the questions were tailored accordingly. As a result, three different sets of interview questions were prepared and used in the study (for the organisers, teachers and students). Although they were designed individually, the aim and the focus used in each was still the same: to understand the impact of science research-based competitions on students' attitudes towards science.

The interviews were divided into two sessions; the first was with the key informants and was conducted in 2009, while the second session was with the participants (teachers and students) in 2010.

Each of the interviews took 45-60 minutes and was held in a quiet room predetermined by the organisation or the interviewee. Permission to tape-record and use the materials was obtained from each participant before starting the procedure. A tape recorder was used in the interviews in order to allow the researcher to give greater attention to the interviewee's responses, to eliminate errors, and to increase the accuracy of the data. However, when needed, note-taking was also practised to pursue new questions as the interview moved along, as, according to Patton (1990), it is a good practice to take important notes about what is being said and to capture non-verbal behaviours that help to pace down the interview.

The official language used in the interviews was Bahasa Malaysia (the Malaysian national language), although the interviewees were allowed to use either Bahasa Malaysia or English, or a mixture of both. Most of the interviewees, especially those from the sponsoring agencies and the students, opted to respond confidently in English. However, teachers and the officer from the Ministry of Education tended to respond in a mixture of the two languages. This was due to their levels of English proficiency and the official Malaysian guidelines for civil servants to respond in Bahasa when dealing with official matters. On the other hand, the students were more comfortable about responding in English when asked about science-related issues as they were taught science in English.

4.3.1.1 Key informants

There were two types of key informant involved in the study. The first was a representative from the Malaysian Ministry of Education. He was the desk officer who was responsible for organising competitions, selecting the types of competitions, and managing funding, trips and training for teachers and students. His job was to ensure that the types of competitions were suitable for different targeted groups, to set up judging committees and competition schedules, and to send national representatives to international competitions and training sessions. He supervised more than twenty science competitions locally and internationally each year. The second type of informant was from the independent organisations which play an active role in the programme. With their own aspirations and agenda towards the success of the programmes, they invest millions of dollars each year for the success of the programme. They outsource sponsorships from various sources in order to organize the programme. Not only preparing the awards, supporting consultations and providing trainers, some of them also provide nucleus work stations for the participants. Three of the most prominent sponsors-cum-organisers in science research-based competitions in Malaysia were selected as informants for the study. They were from a well-known international electronics company which had sponsored an innovation and engineering fair since 1999, a publisher and sole teaching and learning aids distributer which had been sponsoring and organising robotics competitions locally since 2005, and a sponsor coordinating company which had been coordinating sponsorships for a racing car engineering programme since 2005.

Their views and aspirations were gathered by means of a semi-structured open-ended interview. The interviews were each divided into three themes, the overall design of the programme, how it had been conducted and their aspirations. Their collected views were supported by official documents and printed materials. The information was used to justify their aspiration and achievements in the programmes. Had the objectives been achieved? What were the indicators used to mark their achievement?

4.3.1.2 Teachers

The teacher is the key person in every team in any competition. The teacher's role as mentor, advisor and team manager demands a great deal of effort, time, patience and commitment. They are responsible for choosing the participants, supervising projects, and finding funding and sources of external help for the team research projects. Teachers are appointed by the school administration early each year based on their skills, reputation and interest. Most of the teachers who participate in the science research based competitions are experienced science teachers. Once appointed, they look for talented and capable students to be trained up each year. The students naturally are different every year, but normally the teachers will remain in the team for years. They are responsible for guiding the students on how to conduct scientific research, how to find a feasible project within the time frame given, how to outsource the materials and how to set up collaborations with other research agencies when needed. All this is an extracurricular activity with demanding late working hours without any incentive or extra pay.

The interviews with teachers generated an in-depth understanding of the impact of the programme on students' science attainment, on the challenges they encountered and on their aspirations towards improving the programme. They were asked about their experiences in mentoring the team, their perceptions of the ability of the science research based competitions to influence their students' motivation to take up science, learning and understand science through research and innovation activities. Their views on mentoring the programme and their confidence in opening it to more students were also gathered and compared. The findings complemented the views collected from the students, and therefore contributed to deepening the understanding of the activities.

4.3.1.3 Students

The main aim of the interview sessions with students was to understand the impact of students' participation in science research based competitions on their responses towards science. This was done by analysing students' personal views on the programme using semi-structured interviews. Based on the piloted questions, six main questions were set to be used in the study. They asked about what were the influencing factors on their participation, whether participation helps them to understand science better and how it alters their feelings, what their career plans are at the moment, and whether participating makes them alter their plans. Their thoughts about offering more places for their colleagues in future science research-based competitions and the most challenging task they encountered were also sought.

Their views were highly regarded as the heart of the study. Their overall perceptions on the programme and the impact of the programme on their interest in science are a significant contribution to the body of knowledge. It specifically gives a better understanding of the effectiveness of the competitions in developing and sustaining young minds towards science. It therefore works as a benchmark for the efforts made by the policy makers and sponsors.

4.3.1.4 Analysis of the interviews

The raw data gathered in the interviews were transcribed and, where necessary, translated into English. Content analysis was carried out on particular themes, words and concepts which were identified. According to Leedy and Omrod (2005) and Neuendrof (2002, cited in Berg, 2007), "content analysis is a careful, detailed, systematic examination and interpretation of a particular body of material in an effort to identify patterns, themes, biases and meanings". The themes were sorted according to collaborative social research approaches (Berg, 2007) which allowed the researcher to work in the given setting in order to understand the issues between the stakeholders. Analysis of the qualitative data was carried out by transcribing the collected data into text, coding it into labelled categories according to identified shared issues, matching phrases and similar patterns, and sorting it into different themes. There were several labels used according to the sets of interviews conducted. Shared themes were found in each set of informants. The process then moved on to the third stage which involved clustering similar themes into the same categories, while the different ones went into other categories. The sorted materials were then examined to isolate meaningful patterns and processes.

From the statistical analysis, it was found that type of residential school, gender and participation did not contribute significantly to the students' overall attitudes towards science. Therefore, the in-depth interviews with the participants were found to be very useful in building an understanding of the impact of the programme on responses to science. Two distinctive views were identified from the data yielded, that of the experienced group and that of the inexperienced group. The differences and similarities between the groups were explained in detail. Identified patterns were considered in the light of previous research, and sets of generalisations on the impact of science research based competitions were established. The assimilated feedback contributed to an understanding of the programme conducted.

4.3.2 Students' Diaries

Students' diaries are a very natural way to gather data of the sort required in this study. A diary is a personal document of life which records one's thoughts and actions in the light of one's experiences. Although it cannot be measured quantitatively, the data is valuable as it elicits a personal record on a typically focused area. Diaries are usually written in a natural language format and focus on a specific narrow subject. A diary is time-structured and sequential; but it is more detailed and discursive in content and done in a shorter time line. A diary can be conducted in various ways, but not as a sequence of questions as in a questionnaire. As in the content analysis described above, the diaries were analysed according to thematic analysis.

According to Bryman (2008), a diary provides unguided information and a better perspective on the area being researched. Its nature invites the convergence of ideas and experiences in someone's life routine. In diaries, individuals are free to express their feelings and thoughts. Kevin Courtright (1994, cited in Berg, 2007) has listed three distinct advantages of using diaries in research. He claimed that a diary provides a defence against memory decay, is able to provide information about the writer, and allows a reflective recreation of events. However, diaries have a restriction in terms of interaction. They are mainly restricted to informant input. Diaries can suffer from a process of attrition, which occurs when the process is wearing down through pressure of work or stress. There is also the possibility that the diarist will lose interest over time. Thus, failure in recording details quickly leads to memory decay and jeopardizes the data.

In order to minimize these drawbacks, this study used a semi-structured diary (*see* Appendix E) with simplified guided separate columns which guided the informants to record the required information. The instructions were worded in easy questioning statements. Participants were asked to record their fears, any problems they encountered, the solutions they made, any issues which arose, their reflection on the particular week and their aspiration for the week to come. By using this technique, the students were required to fill in their feelings and opinions without any hesitation. They were advised to write down their experiences each Friday for five consecutive weeks. They were also reminded about completing the diary honestly and not inventing anything related to it. The entries were based on five consecutive weeks running from 23 February to 25 March 2010. This five-week period was chosen as it is the most critical period before the competition. This limited five-week time frame was chosen in order to reduce the risk of attrition due to increasing pressure from the project. In order to get a sufficient record, at least four students from each type of school were selected to keep a student's diary. Uncompleted details on interesting points were triangulated later in the in-depth interviews.

There were seven main questions asked of the diary-keepers; the date, what are the challenges you encountered this week, explain how you solved the challenges and what you learned from them, what are your comments/issues on the project, on your peers, on your mentors and on yourself this week, what are your reflections on your experience this week and what are your action points for the coming weeks. They recorded their entries on loose sheets of printed A4 paper and compiled them into a file which they had been given. Permission was also granted for them to write more than one entry per week, and to use any language according to their preference. The completed records were collected on the day of the competition in sealed envelopes. The process was made confidential in order to provide the opportunity for the students to record their feelings freely. From twelve selected students, only nine submitted their diaries. This represents a return rate of 75% from the target sample. Two of those received were disqualified due to insufficient entries and one appeared to be a copy of that of another respondent.

The main focus in the diary keeping was on comparing the similarities and differences between types of schools and types of projects; on how they dealt with the project development, stress, knowledge and emotions against the time-line. Similar themes were identified and are discussed in depth in Chapter 6. The results obtained develop a better understanding of the students' experiences and the teachers' role due to completing the project.
The diary method provided an excellent tool for the study of students' views, yielding fascinating detailed and unique information once it was combined with an in-depth interview. However, it is undoubtedly a demanding method on both respondent and analyst.

4.4 Construction of Key Measures

Having a personal involvement in organizing and mentoring students in residential schools in science research-based competitions from 2004 to 2008 granted the researcher an insightful understanding of the mechanism of the competitions, students' difficulties and their potential rewards, and teachers' challenges. This knowledge and experience was used wisely to design the study and the research flow appropriately and critically. To avoid any unfairness to the study, the researcher's beliefs and personal perception of the impact of participation in science research-based competitions on students' responses towards science were put aside and the following steps were taken to ensure the reliability of the process used.

I. The aspirations of policy makers and independent organisations were articulated via interviews and document analysis. This acted as a bench-mark and drew a guideline for understanding the programme.
II. Triangulation of data was incorporated into each resource used;
    i. Students' views were evaluated from the interviews and the diary entries;
    ii. Teachers' views were gathered from interviews and from students' feedback on mentoring.
III. Pilot tests on the teachers' and the students' views on the programme were carried out in 2009 to inform the interview questions and the format for diary entries. Hence, the guideline for the interviews and the work-frame for the diary entries in the real study were based on the information gathered.
IV. Respondents selected were those who were involved directly in the competitions, which allowed accurate and better understanding of the overall impacts of the programme from various sources. The respondents represented the organisers, the participants and their mentors.
V. The qualitative data on the interviews and students' diaries were examined and had external researcher validation. Analysis of one of five themes found that the consistency between the two researchers was 95% apart from the definition of the concept of attitudes to school science. After discussions, straight agreement was reached and the analysis was carried on.
VI. Data analysis was carried out according to the data collected. The questionnaire responses were analysed using SPSS as practised in the

nationwide study held in 2004; the interviews were transcribed and analysed according to the themes and common words found. The diary entries and printed documents were analysed by content analysis. The gathered data were assimilated and made into an holistic understanding of science research based competitions and their impact on students' responses towards science.

With these precautionary steps taken, it was hoped that a well-balanced study could be carried out in which appropriate steps had been taken to disseminate or minimise any potential bias.

Chapter 5: Aspirations for SRBCs: the Views of Policy-makers and Independent Organisations

Overview

Science research based competitions were officially initiated in Malaysia in 1999 (Intel, 2008). They started when the School Division, Ministry of Education (MOE) worked together with Intel Malaysia and launched an affiliated Intel International Innovation and Engineering Fair (ISEF). Eventually this initiative opened up into various types of science competition such as Olympiad competitions for upper secondary school students and many more were held in the following years. Since then, the MOE has played a key role in choosing, moderating, supervising and sponsoring programmes for students with the most potential in Malaysia. This rapid growth was made possible by the financial support made available from various government and independent agencies.

There are some independent agencies that have been voluntarily and genuinely committed to being involved in conducting science research based competitions for many years. They provide funds, consultation and expertise to support these activities. Most of them work collaboratively with international agencies in organising the events. This opens up more opportunities for the national winner to compete in the international arena. Basically, the main aim of conducting the programmes is to increase students' interest in and awareness of science and technology. They organisers work closely with the MOE in organizing and conducting the events each year with the support of the teachers in schools. However, not all schools in Malaysia have benefited from the programmes; this is due to logistical problems, limited facilities and insufficient funding.

Even with limited exposure and small numbers of participants in its national competitions, Malaysia has continuously been sending teams to compete in the international arena. Over the years, these competitors have succeeded in bringing home several trophies and securing good placing in each competition. This success increases the confidence of the organisers and policymakers in the students' potential and motivates them to venture more into science programmes. This chapter is about their aspirations and aims in contributing to science interest among school students in Malaysia by participation in science research based competitions. Subsequent chapters will focus on the impact on students, allowing a comparison to be made between the aspiration and the reality of the programme in inculcating students' interest in science.

5.1 Involvement and Roles

Science research based competitions demand high levels of commitment and funding from various parties. They involve a wide range of levels of entry and degrees of difficulty, so serious involvement from various government and independent agencies is needed. For many years, governments and science bodies all over the globe have been coordinating programmes to stimulate interest and students' awareness in science. In Malaysia, collaborative ventures started in 1999, which was 35 years later than countries such as Taiwan, Japan and the UK. Collaborative efforts involving all the appropriate agencies and support from the grassroots helped the growth of interest in the programme. This has involved various levels of participation – schools, district, state, national and international, and has provided a platform for the students to share their courage and their confidence in science.

The data collected for this study were based on four in-depth interviews with individuals in charge of the programme and on available supporting documents. The first interview was with the MOE science competitions desk officer, and this was followed by interviews with representatives from the three main independent sponsors: a major electronics company who will be referred to in the study as (A), a local publisher and distributor which will be referred to as (B) and a company which coordinates sponsorships, which will be referred to as (C). The data gathered from these key people interviewed will allow a clear vision to be established of their collective contributions.

Their comments are categorised in three sub-sections; the first is the theme of the question. Four main themes were used in the interviews; background information on science research based competitions (K), conducting the programme (L), experiences (M) and others issues (N). Each theme contained a series of related questions. The second is the number of the question and the third represents the informant: (M) for MOE, and (A), (B) and (C) for the sponsors as described above.

5.1.1 Ministry of Education, Malaysia (MOE)

The MOE has been fully committed to science competitions since 1999. Initially, an officer from the Schools Division was assigned to organise and coordinate the competitions nationwide. After the restructuring of the MOE in 2008, the programme was transferred to the supervision of the Division of Arts, Sports and Co-curriculum. The programme started with Science Innovation and Engineering Competitions, a Mathematics Olympiad, a Physics Olympiad and a Chemistry Olympiad and then developed into more than 20 local and global programmes in 2006, which had doubled to 40 in 2009. Each competition was designed to challenge various levels of students' age and a wide variety of interests. Being in charge of the enculturation of science interest across the nation, the MOE is responsible for:

i. coordinating students' participation, especially in international-level competitions. "The selections were done based on certain rules that been authorised by MOE. For example F1 *inschool* competition, we did the zone competition, national competition then the winner will be selected to representing Malaysia to the international level" (K, Q1-M).
ii. administering the regulation, documents and international aspects related to the competitions; and

iii. managing funds and distributing the allocations. In 2009 there were thirteen international programmes and twenty local competitions nationwide. The one-off allocation was mainly used to support the participants' transportation, logging and other administrative issues. With only 1.7 million Ringgit Malaysia committed, sponsors and extra help from other agencies were badly needed. More funding collected consequently resulting in greater participation.

According to the desk officer, there are two main aims for conducting science competitions among students:

i. providing exposure for students to the international arena, and
ii. increasing students' interest in science.

The competitions were conducted at a range of levels, starting at school level, and then developing through zone/district and state levels and ending at the international level. The most outstanding project in the national competitions is the one which is selected to represent the country abroad. Science research based competitions normally involve a year of a high degree of research commitment amongst the competing school students. Currently there are three main science research based competitions in Malaysia; Intel ISEF, F1 *inschools* and the National Robotics Challenge. These involve various scientific skills and strong content knowledge in very specific areas. In order to assist the students, the Ministry has established mutual arrangements with local universities and other research agencies on the sharing of expertise, funds and usage of facilities. Although there is no specific policy for the programme, there are a number of accepted norms that have been followed by the MOE to monitor the programmes (L, Q2-M). The progress and the development of the programmes are monitored closely by two parties: the State Education Department and the competition organisers. Beliefs in human potential and individual talent remain the main driving force behind the effort devoted to pursuing the competitions.

5.1.2 Independent Agencies

There are three main independent agencies which are involved in organising and funding science research based competitions in Malaysia. They have been sponsoring, organising and supporting the development of the programme locally and internationally for more than five years. Their contributions to the programme are discussed in the following sections on the basis of the interviews conducted and the supporting documents gathered for this study.

5.1.2.1 Company A

Company A is a company well known for its smallest chip innovation in 1971 and has been engaged in developing science and mathematics since the initiative was founded in 1968. Malaysia was the first overseas operation committed to by the main company. It started in Penang, Malaysia, in 1972 and has grown considerably over time. It has a long history of commitment (since 1968) to supporting education programmes across the world. Its main focus is to equip young people with twenty-first century living skills. It has been contributing to Malaysia's education since 1995 when it started to focus on higher education and community programmes. It has contributed to higher education curriculum development, technical lectures and grants for research. From 1999, it has expanded this involvement towards the K12 or Primary-Secondary Education area which comprises science programmes and future teaching and learning programmes (Intel, 2008). These science programmes have involved organising science fairs and science camps at the national level with the Schools Division of the Ministry of Education in 1999.

Its ventures into the area of education are based on three key objectives:

i. to improve teaching and learning through the effective use of technology;

ii. to advance maths, science and engineering education and research; and
iii. to advocate and to celebrate education excellence worldwide.

Company A has organised an annual innovation and engineering competition. These are the world's largest pre-college science competitions that welcome the best young scientists and inventors to come together to share ideas, showcase cutting edge science projects and compete for £2.47 million in awards and scholarships (Intel, 2009). An affiliated fair in Malaysia was sponsored by Company A from 1999 to 2003. Beginning in 2003, the affiliated fair ownership was taken over by the Ministry and has been incorporated into the Ministry's Annual National Science and Technology Education Fair. However, Company A still plays its role in sponsoring the top prize winners and to funding Malaysia's delegation to the international arena on an annual basis. According to the key person interviewed, this programme is a part of the company's responsibility in sponsoring £61.89 million education programmes in the world annually (K, Q3-A).

Since the programme was initiated, there have been approximately 300 innovation projects received by the MOE each year and only 30-35 projects will be eligible to compete in the final. The projects are judged and only the top six are nominated as winners. Up to 2010, 74 students in total have been sponsored by company A to compete at the international level. A total of sixteen of these students (22%) have won various prizes at the international events.

The programme is monitored by MOE desk officers and the aim was to see talent growing in the area of innovation: "We hope it will cater for the industry needs and national requirement" (K, Q10-A).

5.1.2.2 Company B

Company B is a well-established publisher and authorised distributor of educational teaching and learning aids in Malaysia. It has been collaborating with the MOE and the Ministry of Science, Technology and Innovation Malaysia (MOSTI) in organising the robotics challenges since 2005 (Official Web Site for Co-curriculum and Culture, 2011). This was initially started as an experimental event to help schools to use robotics as a co-curricular activity but has now become an annual event that is a highlight in the school calendar (M.Dom, 2009). The main intentions of the project are:

i. to help students to build a solid foundation in mathematics, science, technology, design and ICT through hands-on experience or investigation;
ii. to train students to work together to solve challenging problems in a spirit of cooperation and collaboration;
iii. to enable students to develop logical and systematic thinking as they plan and implement programmes through the programming of robots;
iv. to enhance students' creativity in problem solving and raise their awareness of the many possible ways of arriving at a desired outcome; and
v. to promote competition in robotics amongst Malaysian school students as a healthy and fulfilling pastime.

Company B's vision is to provide a powerful learning platform to enable students to cope with skills that are essential for success in the twenty-first century.

To date, Company B has been actively selling robotics kits, conducting training, sponsoring awards and sending delegations to the international robotics competitions each year. It has established various challenges for children of different age groups; primary, secondary and an open category. These involve an intermediate level of research skills but focus more on the technical aspects of the challenges and on problem-solving acquisition. This is clear from the challenges which are set, the resources (Lego) which are used in the competitions and shorter time frame (two to three months) for preparation. In 2009, the company spent £0.3 million on technical guidance and prizes for the local competitions.

The programme is monitored by the company's technical group under the supervision of the Sales Director and the MOE desk officer in each state. The aim is made clear: "to enable more students' involvement in robotics in their future undertakings", (K, Q10 B).

5.1.2.3 Company C

Company C is a company which coordinates sponsors for a motoring competition. It started its operations in Malaysia in 2005. The competition is an event to celebrate young people's ventures towards design engineering, specifically of *racing cars*. The main aims of the programme are:

i. to increase students' interest in science and engineering, including the soft skills such as marketing and leadership;
ii. to expose students to the most realistic experience in the real world of Formula 1 racing;
iii. to increase the interest and number of students in engineering; and
iv. to provide a channel for sponsors to help schools in nurturing students' interest in science and engineering.

(K, Q3-C).

The company's main role is outsourcing sponsors to fund the competitions. It uses the funding acquired for sponsoring the programme training, providing CAD/CAM training support, maintaining the hubs and employing an event manager. The competitions involves three stages; regional, national and international competitions. The challenges involve a high degree of science research as the students need to engage themselves in various areas of scientific knowledge; physics, aerodynamics, manufacturing technology, sponsorship, design, marketing, branding, speed and others to which there is only limited exposure for them in the school science syllabus. The participants spend almost a year preparing for the competitions. The challenges include a speed race, presentation, marketing and car design (F1*inschools*, 2006).

The programme is jointly monitored by the MOE state desk officers and the company's state-based engineers. These are the ones who visit schools and coordinate the facilities in the hubs. They assist the teams on the soft skills and on the techniques involved in crafting a racing car from a box of balsa wood.

5.2 Aspirations

> "We do win awards, but we hope for a better placement. We need to compete with Asia Pacific Region. Our performance is a far cry from Taiwan and Thailand." (M,Q1- A)

Is winning the only aspiration the organisers have in mind? Or is there anything else that is more pertinent to them? On the face of it, being corporate organisations which are accustomed to competitions and achievements, it is not strange for them to respond in such a way. The issue is, however, how does the MOE involvement fine-tune the programmes to ensure that they are sufficiently educational rather than too business-like? This sub-section explains the holistic aspirations gathered from the interviews with the key informants on the organising of science research based competitions in Malaysia. It is divided into two parts; the scientific element and the programme administration.

5.2.1 The scientific element

In this section, information on aspirations is grouped under three headings; the aspirations to increase students' interest in science and technology, to expose them to realistic science challenges, and to create greater participation.

5.2.1.1 Increasing interest in science and technology

The Ministry has set out a number of criteria for the organisation of science research based competitions. The competitions are intended not only to open up greater exposure to a higher degree of competitive participation, they are also aimed at motivating students to have greater interest in science and to provide experience for the MOE officers in conducting and organising international competitions in the near future (L, Q1-M). In order to open up exposure to the international arena, collaboration with large companies which are involved directly or indirectly in organising international competitions abroad turned out to be the best solution. In response to the social commitment, independent organisers are willing take part with their own aims. For Company C, the major aim of sponsoring the competitions is to increase students' interest in science and engineering, including the soft skills such as marketing and leadership. While Company A targets the growth of students' talents in the area of innovation, Company B aims to encourage students' interests in robotics. Generally, therefore, they are specifically interested in inculcating interest in science; namely innovation, car engineering and robotics. By contributing to the competitions, they hope that they will nurture sufficient talent to meet industry's needs and requirements. With a higher interest in science, hopefully the younger generation will have more confidence in their abilities and be better equipped with twenty-first century life skills.

5.2.1.2 Exposure to the most realistic experiences in science

The opportunity to compete abroad has been seen as one of the attractions of participation. In fact it was stated as one of the main aims by the Ministry official; "... to increase the quality and world ranking [of Malaysia] in every competition participated in" (N, Q1-M). Although the numbers of places available is fixed to the three categories in each type of competition, there is still a huge impact in participating. To secure a place and to be determined to set new records remains the biggest challenge for participants. This provides competitive experience and increases the quality of the tournament. As the participants are motivated towards winning, the science challenges seem to be interesting to them and worth pursuing. Recently, students have been involved in biotechnology, a great deal of applied mathematics, herbal medicine and environmental projects (M, Q1-A). The challenges which they encounter while doing research and innovating projects provide them with endurance and persistence in the context of the reality of science. They are becoming more adventurous and creative in their projects (M, Q1-B,C). This will hopefully open up their minds to the interesting prospects of a science career in their future undertakings.

To improve choices and to create greater competitiveness in world challenges, new games rules and challenges are introduced for the participants to conquer: "We change the rules and regulations every year to make it tougher", (M, Q3-C). With their heightened interest and determination, participants have addressed each new challenge impressively with new strategies and creative solutions. "We noticed that the students are getting more adventurous and reaching the world ranking. The regional level too has shown a tremendous achievement. They managed to come up with different gadgets to help them to compete in the competitions", (M, Q2-C). The hurdles which are set up not only act as a filter to identify the greatest talent, but also challenge the students' creativity and determination: "The students become more creative, especially in the open category," (M, Q2-B). Therefore, higher quality responses and more competitive projects are produced each year. With more projects generating greater capability, the MOE has the privilege of being able to choose the best project to compete internationally (M, Q2-M).

5.2.1.3 More participation

It is the aspiration of the independent organisers and the policy makers that the number of independent organisers will also increase with time. This will eventually open up more chances for students, especially those who are in the rural areas, to share their talents.

> "I want to see more involvement from the rural schools in Malaysia. All schools should benefit from this kind of programme for years to come" (N, Q1-M).

> "We can't pull everyone in to do projects, it is just that we need to get a larger percentage of students involved in this kind of competition" (N, Q1-A).

> "We really wish the rural kids will have more exposure and will challenge themselves in this kind of competition" (N, Q1-C).

During the interviews, there was a suggestion made on how to increase the amount of interest and widen the talent search: "[There should be] more courses in teachers' training colleges on robotics and in technical schools, so the knowledge would be expanding all over the nation" (N, Q1-B). This suggestion seems to be practical and do-able. It will take determination to restructure the strategies to increase participation and awareness as part of current developments in science.

Over their years of involvement in competitions, the key informants have developed positive beliefs in the competitions as they have witnessed the growth of students' potential and the development of their talents, their determination and their creativity. Without the participants realising it, they have developed their talents through the confidence they have learned to build on in science. However, no-one knows the real impact of the competitions as no study has been conducted on it (M, Q7-M).

> "It has not been measured – [for] our indicator, we look at the end product. If the end product is good, so it can be inferred that the process is conducted according to science discipline". (M, Q7-A)

> "Hasn't been measured". (M, Q7-C)

> "Haven't measured it yet, but most of the students who have participated in the competition went on to engineering schools after SPM", (M, Q7-B).

However, there is no viable database which could be used to support the claim made by this interviewee.

5.2.2 Programme Administration

In order to establish interest in science among students, and increase the pool of potential human capital in science, the key informants listed their long-term aspirations for the programme. These incorporated funding, talent search and the overall focus of programme improvement.

Funding is the most important driver to attract potential and interested students from all over the nation to participate. As was mentioned in the interviews, "I hope there is an increased budget allocation from the Ministry for science research based competitions each year, as I want to see more involvement from the rural schools in Malaysia," (N, Q1-M). This interviewee also hoped for increased financial support from the community, independent organisations and other agencies. With financial support, more opportunities and facilities can be made possible for all. This is in line with a response made by one of the independent organisers:

> "Taiwan runs it well; they give lots of exposure to their potential students especially in innovation competitions. They are granted a

special grant from their government (Ministry of Science) and are well supported by their local scientists in the universities. They in fact have their several [of their] own league of science competitions. They have sent their winners to various kinds of science competition around the world. Only the best amongst those who compete will be representing Taiwan to the Intel ISEF each year", (M, Q1-A).

This claim was checked and verified. The Taiwanese 2009 report states that Taiwan started to participate in innovation and engineering competitions in 1982. From 1982 to 2008, 51% of their projects won Grand Awards at ISEF. They incorporate two main support systems; universities and research institutions, and government initiatives. Both of these have been actively involved in providing laboratory equipment and resources, running a mentorship programme, conducting an international science fair, and organising high-school science research programmes and science project workshops for students and teachers. The government subsidizes the students' research and acknowledges the projects by accepting the project work into their international science fair board. Furthermore, they guarantee university admission for ISEF grant award winners and recommend university admission for non-winners. Scholarships were also awarded to grant award winners to attend prestige overseas universities (Intel, 2009). According to a follow-up study of the ISEF Finalists from Taiwan;

i. all former winners have remained in science, engineering or medical disciplines, either working as research scientists or engineers, or studying as PhD/MSc/BSc candidates with a science major;
ii. winners have out-numbered the percentage of non-winners in attending graduate programmes, pursuing doctoral degrees, selecting academic careers and publishing research papers; and
iii. Taiwanese ISEF finalists portray certain personality traits, such as a passion for science, curiosity and persistence in tackling challenging problems. (Fung, 2006)

The serious focus on science and technology shown by the Taiwanese government, especially in respect of the growth of science literacy amongst young people in Taiwan, is clearly shown by a statement made by the Prime Minister of Taiwan, Liu Chao-shiuan, in 2008: "We hope to inspire more foundations and corporations to be sponsors for the science fair" (Intel, 2009).

The key informants' aspirations revealed in the interviews in regard to the need for additional funding for the Malaysian programme are considered to be entirely reasonable because, since 2000, there has been an increase of interest amongst students in science research although the opportunities given have remained the same. The growth of science interest and the increase in opportunities do not expand in tandem due to the lack of funding: "the [Malaysian] government should give more grants to this type of competition," (N, Q1-A). Furthermore, a variety of activities involving industrial experiences should be added accordingly:

> "We [Malaysia] do not have lots of projects that are related to industry which interest the sponsors. What we are doing is to involve more real experience for the youngsters [as an introduction] into the real world of industry and technology", (N, Q1-C).

The search for talent has been the biggest challenge for teachers. Without knowing what skills are needed, what challenges will face the students and what strategies will be involved, the teachers would be likely to misdirect the talent they find. With no research background, students aged from fifteen to seventeen rely on their teachers' guidance for the research skills that they need in order to participate. According to the Ministry officer, "Teachers' commitment and school management play a major role in winning projects". This is found to be a sensible observation as the records show that the winning teams usually come from the same schools with particular mentors. The teachers are the ones who push the projects (M, Q5-A) thus contributing to the development of the students' talent. Therefore, the teachers need to be given more skills in how to conduct research and run a systematic programme in schools. They should be exposed to many idea-sharing sessions, especially on their experiences as teachers (N, Q1-M). Full and appropriate training on current science issues and the techniques available would be considered an investment in yielding potential projects and talents.

With the expansion of interest and of the numbers of participants in the programme, the MOE monitoring mechanism should be more focused. Relying solely on one person to coordinate and run the show across the nation is absurd: “The programmes need to be more focused and there should be more key persons in MOE who are in charge in this kind of theme” (N, Q1-A). It is believed that the more key officers there are in the MOE, the more focus there would be on the programme. More interest in science research and innovation would be generated and monitored. The focus on conducting and organising science research competitions is essential according to the needs of Vision 2020. The aspirations of the supporting organisations are aimed at stirring up interest, identifying potential, developing talent and also hoping for related progress of the students after accomplishing the programme. With a more structured organisation, the programme would be more focused and therefore more beneficial to national development.

5.3 Achievements

> “The success of the National team in this international competition will become another showcase for the capabilities of the Malaysian education system in producing students of excellence”.
>
> Dato’ Seri Hishamudin Tun Hussein,
> Minister of Education, 18 October 2005.

Being a recent arrival in the field, Malaysia is catching up with other countries in nurturing her students’ potential in science competency and acknowledging their achievements appropriately. Winning in various international competitions is the fastest way to register Malaysia’s ability in the global arena. Creating global players who are equipped with all the pre-requisite characteristics needed in an industrialized or developed nation is a part of the national blueprint in Vision 2020 (F1*inschools*, 2006). Therefore, positive publicity from the competitions provides a showcase for the education endeavour as one of Malaysia's developments.

Achievements in the programme depend on the completion of the objectives set. Collectively, the four informants shared three common objectives; to increase interest in science, in awareness and in exposure among students. From the information gathered, there are measurable achievements which are feasible to be observed by the naked eye and analysed statistically, and on the other hand, there are less tangible achievements which are only assessable after thorough long-term study. Both types of achievement are pertinent in evaluating expensive and popular programmes such as science research based competitions.

5.3.1 Measurable achievements

5.3.1.1 Interest in science and technology awareness

There is a steady annual increase in student participation in the competitions, especially in robotics and designing racing cars. For example, the robotics competitions started off with only approximately 100 teams in 2005, which more than quadrupled in 2006 to 473 teams and increased thirty-fold to 3000 teams in 2007, and kept on growing to 3200 teams in 2010 (Sasbadi, 2010) (Sasbadi, 2009). For designing racing cars, the popularity of the challenge has grown at a similar rate, started with only 54 teams in the first year (2005), quadrupling to 214 teams in 2006 and increasing more than 34-fold to 1700 teams in 2010 (F1*inschools*, 2006). The progressively larger number of teams registered each year shows the students' enthusiasm for the recent scientific developments.

Accordingly, with the increasing numbers of participants over the years, there has been an expanding number of hubs and competition zones throughout Malaysia. For example, robotics competitions started with only four zones throughout the Malaysian peninsula in 2005 and developed to seventeen zones in 2009 which covered the whole of Malaysia (Sasbadi, 2010). Both activities are considered as the most popular activities and trendy in schools, and they successfully attract the brightest students. At the same time, they provide exposure for the other students to new engineering fields.

The increased exposure to science offered by the MOE and affiliated agencies in just a few years is a positive indicator of the building of science interest amongst students in Malaysia.

On the other hand, the innovation competitions, which require higher levels of commitment, scientific research skills and time, have not really enjoyed the same wave of popularity as robotics and racing cars, especially in terms of the number of teams registered. The number of participants is almost static (n=300) and is especially limited in the annual national science carnival (n=35) (Official Web Site for Co-curriculum and Culture, Ministry of Education, Malaysia, 2011). However, this does not imply any reduction in interest and awareness amongst students. With the nature of the innovation and engineering competitions, each interested school would only be able to put effort into sending one team a year. Although the number is almost static, the quality of the innovations is increasing congruent with the placings gained at international innovation fairs (N, Q1-M).

Furthermore, the increasing numbers of innovation competitions around the nation each year shows positive awareness from various sectors of the need to inculcate research skills to young Malaysians. Local universities, science bodies, MOSTI and science-based government agencies have successfully organised well-structured science research based competitions which cover almost all facets of science, including medicine, health, chemistry, physics, agriculture and biotechnology. Certainly, innovation shares the same triumph when the young participants manage to come up with lots of innovative and marketable ideas. Although the number of participants is small in each innovation competition, the number of events is expanding as their value becomes more widely recognised. Unfortunately, there is insufficient data on the number of participants, as most of the events are coordinated individually and not jointly coordinated through the MOE. The acknowledgement of this development is being publicised and was addressed by MOSTI through the establishment of a National Innovation Award for students in 2006 (MOSTI, 2009). With the recognition and the involvement of all the relevant agencies, students' and public interest in science is developing all the time.

The increasing numbers of participants and of competitions reflects the successful expansion of science and technology across the nation. Interest in science among students is reckoned to be increasing partly through the challenges and activities contained in science research based competitions. However, this does not indicate the level of awareness. There is a need to explore the level of awareness, which depends on the quality of the issues and the interpretation they put on understanding the importance of research. Students' participation might be driven by the challenge, by interest, or simply by curiosity to explore something new, and not really related to their awareness of science itself.

5.3.1.2 Potential and talent

Malaysia won the fastest car R-Type in the international competition held in Birmingham, in the UK, on its first attempt at competing in the international arena in 2006 (F1*inschools*, 2006) and has continued to win in various categories over subsequent years.

With equal exposure and standardized tools and rules applied worldwide, the competitions have been able to measure strictly students' creativity and their talent in dealing with the challenges set. With the same starting line, it is feasible to identify the real potential and ability shown by all participants. It was a triumph for the nation in 2006 when the first attempt yielded such a promising signal of young Malaysian's potential and talent.

Robotics and racing car engineering competitions work very well in cultivating and nurturing students' potential to its fullest. These competitions have a standardized challenge set annually across the world and all participants use the same provided material. Furthermore, the challenge incorporates multi-tasking chores such as designing, programming, project management and knowledge of science. On the other hand, innovation competitions involve bigger subject areas with scope for limitless exploration. Participants have the freedom to explore the particular aspect of science which interests them most. What matters in innovation is the scientific skills used and how the participants answer the hypothesis, together with the soundness of the data analysed. As well as involving a higher level of research, innovation competitions allow the students to show off their real potential and talent in science research from scratch. Thus, winning in this type of competition very definitely acknowledges and confirms the talent possessed by the successful participants.

Different types of competition offer different types of challenge. Whatever the challenges are, being eligible to compete and share their confidence in science definitely raises participants' motivation and self-confidence. Being selected as participants or becoming winners in these challenges endorses their potential and their talent in the science field. In other words, these competitions celebrate everyone's talent appropriately.

5.3.1.3 Skills and content knowledge

Over the years, Malaysia's teams have been winning in various science programmes. From the records, it can be seen that 22% of the contestants sent to Innovation competitions since 2000 have successfully secured good placings (Intel, 2008). Participation in international robotic competitions has also shown tremendous results, and Malaysian competitors have continually won Gold Medals in the Senior High School (open category) since 2007, the most popular team award (primary schools) year after year, and various other awards (Sasbadi, 2009). According to a foreword written by the Minister of Education in 2010 (Sasbadi, 2010), “Being overall champion at the World Robotics Olympiad in 2009 demonstrates that our students are on a par with those in developed countries”. The list of wins is long and impressive, confirming the students’ potential in science areas. It elevates and highlights the potential of Malaysia’s young generation and of the country’s education system.

The records show that students have become more competitive over the years. According to the key person in the car engineering competitions,

> “We have noticed that the students are getting more adventurous and reaching world ranking. The regional level too has shown a tremendous achievement. They have managed to come up with different gadgets to help them to compete in this competition.” (M, Q3-C)

Students’ competency in the respective areas has been shown by the increasing numbers of trophies and awards won. New records have been set each year, and this is due to the improvement in the students’ skills. Their increased skills are built during the research and preparation period over years of exposure. This was also admitted by the MOE officer (M, Q2-M) who agreed on the increases in the quality and the quantity of projects submitted each year. This allows a wider choice for the MOE to select the best candidate to compete in the international league.

Although the activities are extracurricular, the application of some science knowledge taught in classes has been fully utilised in the activities. To be able to win in any competition, participants must definitely possess sufficient science knowledge and skills in order to assimilate related science knowledge into new creative solutions to the problems or rules set. According to the key informants, “If the end product is good, so we infer that the process is conducted accordingly to [proper] science discipline”, (M, Q7-A). However, as no specific measurements have been taken on the increase in knowledge and skills developed, anecdotal innovation and success stories are the only evidence of the developed skills and passion for science.

5.3.2 Less tangible achievements

The objectives and aims stated by the key informants in respect of stimulating interest in various fields of science (research, innovation, robotics and design engineering) are encouraging, however it is admitted to be difficult by the organisers to measure this. Nevertheless, evaluations of the programme have been carried out by the sponsors. Most have concentrated on the students' performance and the achievement of the programme itself (M, Q4-A, B, C). There is no evidence on the participants' responses to science, their science literacy or their intention to pursue science-based careers after completing either competitions or national examinations (M, Q7-B, C).

> "We are committed to finding the numbers of participants who eventually join science, especially engineering, after the competitions. Thus this is one of our commitments to our main sponsors; however, we haven't outsourced any data as it needs a lot of work in tracking all the students after the competitions", (M, Q7-C).

This statement makes it clear that there has been no initiative taken to monitor the progress of the talent identified or any special programme carried out to ensure the progress of their capabilities in science either by the MOE or by the independent organisers. Despite the investment of a great deal of effort and money in it, the programme remains just like any other 'competition' to the participants. This is rather a shame as the filtered and identified talented young Malaysian students could be further trained to become the next generation of elite scientists. The MOE officer expressed the hope that in the future there would be more incentives to students who participate at the international level by giving them more merit points to enable them to secure at least a place in the local university. It is hoped that this would show appreciation of their contribution to the nation, and celebrate their efforts and talent, while at the same time motivating other students to participate in such activities (M, Q3-M).

Malaysia should be more focused in utilising the talent which is identified for the benefit of the nation's development (N, Q1-A). Hitherto unmeasurable criteria relating to the responses, science literacy and ambitions of participants should be established in longitudinal studies in order to maximise the effectiveness of the programme and enhance the potential and the talent which is generated. This is in line with a response made by one of the organisers: "We have initiated our part; it is up to the MOE to upgrade its project performance", (M, Q3-A).

5.4 Reflections

Undoubtedly, the key informants have put effort into realising the written aspirations as part as their contribution towards the development of human capital in Malaysia. This mutual relationship brings benefits to both sides. The education system gains help in the form of technical advice and sponsorship, while the independent organisations benefit by regarding competitions as a part of their entrepreneurship deals. With the increases in research and innovation activities, there are corresponding increases in the demands for computers and robotics sets, and in public confidence in investing in the human potential of young people. However, that is only on the surface of the main purpose of organising the programme. The impact on the educational agenda of inculcating scientific skills, science awareness and confidence in taking science as a career is still unknown. No specific measurements have yet been taken by the MOE to monitor this development.

Human potential should be developed and talent should be sought in order to build the nation. The filtered product of hard work should not be wasted. Follow-ups on the identified potential of individuals need to be carried out in order to maximise the benefit and accelerate the speed of human development. The MOE should have more say in identifying projects, promoting competitions, organising funds and programme monitoring, in order to make the programme accessible to more youngsters in Malaysia. The interest shown by the students should be used to challenge their capabilities in order to identify more potential and talented individuals. The MOE should have greater aspirations for the programme as it involves their clients' (students') time and effort and the support of schools. Aspirations stated about simply increasing interest in and exposure to science are already out-of-date and urgently need to be revised. If it is worth doing, more constructive measures need to be introduced for its betterment, and if it is not, then probably it is high time to venture into something more productive and meaningful for the sake of human and national development.

Aspirations should not remain the same for years, especially when dealing with human development. They must progress with time and space. More and newer aspirations are needed to realise Vision 2020 and this has to be clear to everyone in order to reach a realistic target.

Chapter 6: Students' Perceptions of Science

Overview

This chapter is divided into four sections. Section 6.1 provides descriptive information on the six boarding schools which were selected for the study. It elaborates on the location, history, academic and non-academic achievement of each of the schools as well as their involvement in science research based competitions. Section 6.2 explores the overall residential school students' scores on responses to science with a comparison with data from sixteen-year-old non-residential Malaysian students gathered in 2004. The differences between the factor analyses and the scores of these two groups are highlighted and discussed.

6.1 Description of the Schools Used in the Study

Six residential schools in the centre of Malaysia were chosen to participate in this study. They represent all-boys schools, all-girls schools and co-educational residential schools. In order to protect the anonymity of the participants, all personal information collected was considered privileged information and the identities of the schools, the students and their teachers will remain confidential. Consequently, the schools will be referred to as B1 (boys school one), B2 (boys school two), G1 (girls school one), G2 (girls school two), C1 (co-educational school one) and C2 (co-educational school two).

All of the selected schools had Form 1 intake (at age thirteen) and offered pure science classes to their Form 4 students. The sample students were Form 4 students aged sixteen. The questionnaire which was administered was based on that used in the ROSE study of Malaysian students in national schools held in 2004, with small adaptations to suit the specific purposes of the present study. The distribution of numbers varied according to the schools and the responses obtained.

Table 6: Distribution of samples according to types of school

Types of school			Frequency		Percentage	Cumulative Percent
Residential Schools	All boys	B1	61	125	34.6	34.6
		B2	64			
	All girls	G1	60	120	33.2	67.8
		G2	60			
	Co-ed	C1	57	117	32.3	100.0
		C2	60			
	Total			362	100.0	
National Schools			1581		100.0	100.0

Table 7: Distribution of samples according to participation in science research based competitions

Types of participation		Frequency	Percentage	Cumulative Percent
Residential Schools	Others	12	3.3	3.3
	Innovation & Engineering	30	8.3	11.6
	F1*inschool*	6	1.7	13.3
	Robotics	14	3.9	17.2
	Rocket	16	4.4	21.6
	Solar	3	0.8	22.4
	Non	281	77.6	100.0
	Total	362	100.0	

There were 362 respondents (*see* Table 6) comprised of 51.4% girls and 48.6% boys from the six residential schools, whereas 1581 respondents comprised of 46.5% girls and 51.2% boys were recorded in the national schools study carried out in 2004. The great majority of them were in their sixteenth year of age. The residential schools sample was made up of 34.6% from all-boys schools, 32.3% from all-girls schools and 33.2% from the co-educational residential schools. In the samples (*see* Table 7), there were only

22.4% of students who had participated in science research based competitions, specifically 8.3% in science innovation competitions, 4.4% in rocket launching, 3.9% in robotics competitions, 1.7% in F1*inschools*, 0.8% in solar competitions and 3.3% in other competitions. And from the 22.4% of the participants who had taken part in any science research competitions, only 40.1% of them had successfully won an award in the competitions.

6.1.1 School B1

B1 was a residential school for boys established in 1963. It was the first Malay boys school to offer a sixth form (pre-university) and the first residential school in the country to offer Malay medium classes. After forty years in Kuala Lumpur, in 2003 this school moved to Putrajaya, the federal government administrative centre in Malaysia. Recognising the potential to produce numbers of ministers, key personnel for both the private and the government sectors, leaders and professionals, the government has spent 24 million ringgit on a new campus building in acknowledgment of the school's contribution to Malaysia's development. B1 has flourished accordingly over subsequent years and the school's performance in the new location is now widely accepted. It is well-known as one of the nation's educational hubs to educate and produce successful, capable male leaders for Malaysia's future undertakings. For that reason, it is not surprising that B1 was selected to be one of the pioneers of the cluster of excellent schools in Malaysia in 2007, and was awarded the status of 'High Performance School' by the Ministry of Education in 2010. High Performance School (HPS) is a title or recognition given to schools with the necessary ethos, character and unique identity to excel in all aspects of education. HPS schools have a tradition of high culture and excellence in terms of national human capital and the ability to continue to grow holistically and be competitive in the international arena.

B1 is also well known for its record of excellence in four main areas; English debating, its orchestra, rugby and its students' English acquisition. Students from this school have won almost all of the competitions in the area for many years. In 2009, the school developed a serious interest in science and technology, particularly in robotics. B1's students have represented Malaysia in the international arena in robotics competitions for the couple of years since 2009.

Being a hub for 800 to 850 selected high-achieving male students in Malaysia, academic performance has been the main priority for B1's administration. There are two types of main government examination; Lower Secondary Assessment (PMR) and Malaysia Education Certificate (SPM). Even so, despite being constantly burdened with a great deal of extra commitments and school activities, B1 has consistently produced approximately 80% of its students with straight As (since 2003) in PMR, and roughly 20% of all the students obtain straight As in SPM. In SPM, the students perform very well in languages, mathematics and all general subjects, but not as well in chemistry and particularly so in biology and physics.

In 2010, B1 sent two projects to the Residential School Science Innovation and Engineering Competitions, 'i-wuduk' (an ablution water system) and 'Re-cycling Nitrogen Waste at River Bank'. They won bronze and silver awards for their research. Their science teams are supported in terms of both morale and funding by the school's administration, alumni and students' parents.

6.1.2 School B2

B2 is the oldest Malay boys secondary school in Malaysia. It was established in 1956 and has survived several relocations, changes and different educational systems. It has been relocated into three different states in Malaysia since it was founded. Currently, B2 is situated in a suburban area of the capital city of a state in Malaysia. Although it is far from the city centre, the 40-acre school compound is equipped with all the best facilities available in the country.

Being one of the oldest of the Malaysian Residential Schools, B2 is strongly linked with the traditions and the culture of the system. This means that the school has good reputations for its debating teams, its orchestra, basket ball, hockey and rugby. Recently, B2 has started to put positive energy into the science and engineering areas. It has emerged as one of the most competitive teams in F1*inschools* since the introduction of the game in 2008. In 2010, the school team 'Raluca F1' successfully won first place in the international 2010 F1*inschools* competition in the knockout category. In science innovation and engineering competitions, teams from the school have been actively involved in various research areas since 2000. Although they have not been successful in gaining a place to represent Malaysia in this arena, they have reached the finals each year. In 2010, B2's teams produced two interesting projects, 'Levende Friske $O_{2'}$ and 'Using *Pelargonium radula* as an insect repellent'. Both projects were honoured with silver medals.

In academic activity, B2 has successfully nurtured large numbers of bright students for the nation. In 2003, 100% of the students achieved straight As in PMR and they were also in the top twenty in SPM. The school's consistency in producing male leaders for Malaysia's future for years earned it a place in the Excellence Schools cluster in 2008 and two years later it was granted a place in the High Performance Schools league.

6.1.3 School G1

G1 is an all-girls residential school located in the prime location of the Multimedia Super Corridor (MSC Malaysia). It was established in 1968 in the heart of Malaysia, Kuala Lumpur. As with other residential schools, the rapid development of education has seen the demand for expanding the school's capacity and facilities. It has undergone a few changes in name, location and education system which has created lasting endurance for the school in educating the female high achievers of Malaysia.

Since 1978, G1 has had a good track record in producing students who portray beauty, dignity and leadership. G1 is well-known for its academic capabilities. Almost every year, G1 produces more than 85% of straight As in PMR and about 20-28% of its SPM students achieve straights As. In 2010, G1 was ranked twenty-third among the sixty residential schools, with 27% of its students successfully scoring straight As with school total accumulative points of 1.84. In co-curricular activities, this school is well-known in three major niche areas: basket ball, music (orchestra), and information and communication technology (ICT). Its long history has given it the privilege of dominating the women's basket ball team title. In addition to all this, the school's current location in MSC has granted it many ICT facilities. G1 was the first school in Malaysia to be equipped with Fibre to The School facilities. This enabled free flow of students' access to the internet and allowed students to bring their own laptops to school. This is a great privilege in terms of the students' school experience.

Blessed with excellent ICT facilities and a strategic school location near to Putrajaya, and surrounded by more than three local universities as well as research and development agencies, G1 enjoys first-hand experience of the science and technology and the research and development opportunities which are introduced to the country. It is also actively involved in an internationalization programme which involves the exchange of educational programmes, enhancing the school's niche areas and empowering its students' leadership capabilities. With all its excellence in achievement, G1 was honoured to be nominated a pioneer school in the excellence cluster in 2008 and a high performance school in 2010. With its superb reputation, the school has been granted autonomy in various areas, especially in empowering its academic performance and niche activities.

Each year, G1 is actively involved in most of the science research competitions. Its students have shown their capabilities in F1*inschools*, robotics and science engineering competitions. In 2010, it sent two innovation projects to the residential school's science innovation and engineering competitions: ‘The production of organic disinfectant from the tannin extract of *Acacia mangium*’ and ‘The ability of saponin in the husk of *Durio zibenthinus* to be used as a plant growth promoter’. Both projects won bronze awards.

6.1.4 School G2

G2 was the first fully residential and the oldest girls school in Malaysia, founded before the independence of Malaya (Malaysia) in 1947: it has been producing leaders and professionals for Malaysia ever since. Over the years, G2 has stood tall among the residential schools in Malaysia and has achieved numerous successes in curricular and co-curricular fields. Located in the strategic area of a capital state in Malaysia, G2 has every facility and enjoys easy access to all resources. It was nominated to be in the pioneer group of schools in the excellence cluster in 2008 and a high performance school in 2010. With its long history and ethos, G2 has produced three government ministers, the first female lawyer, the first female vice chancellor, the first director of Malaysia’s astronomy agency, prominent academic and non-academic leaders, business women, scientists, politicians and leaders in many more fields. Over the years, G2 has been firmly in the top five schools for PMR results and the top twenty in SPM. Without fail, G2 has continuously contributed to the total list of the national best students yearly. Each year, approximately 30% of the students have been granted scholarships to study abroad by various government and non-government institutions.

There are four niche areas which are dominant in G2: multilingual acquisition, research and development activities, the wind orchestra and leadership. The students are free to choose and learn their third language – French, Arabic or Japanese, and this makes them eligible for scholarships and is a value-added criterion for their leadership credibility. The school has its own module for ensuring the sustainability of its niche areas. For research and development, it has its own dedicated unit which teams up students, teachers and staff in various science areas. With funding from its parent/teacher association, it has been able to set up its own technology park with an open area for students to design and practise their own robotics and F1 models, and also to carry out research development activities during their free hours. The school's determination to create a reliable flow of future leaders stimulates G2 to work far beyond the norm in all educational aspects. It has represented Malaysia and has won awards in international science innovation and engineering competitions for five consecutive years. In 2010, G2's research and development team came up with two projects: 'A fishy detector' and an 'Antidote board'. The fishy detector secured the first place in the innovation category while the antidote board took a bronze medal in the engineering category. Subsequently, the fishy detector was selected to represent Malaysia and was successful in winning fourth place in the grand award Intel ISEF 2011 in the US, and continued to win various national and international innovation awards throughout the year. Furthermore, in robotics and F1 competitions, the girls in G2 have created a name for themselves in both areas regardless of their gender. Interestingly, they actually practise research not only in classroom science but also in their daily activities, including marching, drama and leadership challenges.

With the capacity to accommodate only 820-850 students and under pressure to retain its high track record, G2 has the privilege of being able to select its own students. Each year thousands of applicants compete in order to secure a place in this premier girls school. As a result, the girls who are selected are those who are the cream of the crop of the nation and have high potential in many fields.

6.1.5 School C1

C1 is a co-educational school located about thirty kilometres from the capital city of Malaysia. It is situated in the middle of Selangor forest reserve area. It was established in 2000 as the 38th residential school in Malaysia. Like the other residential schools in Malaysia, C1 is also equipped will every facility but has the added advantage of beautiful scenery. C1 was the first school to practise the 'lecturing' style of teaching and learning, in which the students have to move around the school according to the timetable, instead of the teachers. At the time of this research study, there were about 810 students in this residential school.

The school is well-known for its four main niche areas; debating, rugby, uniformed organisations and mathematics. However, the administration is very supportive of venturing into new areas to ensure the development of the students' talent. The students are therefore exposed to various fields including science activities such as science research based competitions. They won first place in the residential schools' innovation and engineering competition in 2004 and more recently (2011) they won an international award in the F1*inschools* competition in the Team Portfolio Award and Axis categories. Being young in the residential school league does not grant C1 any excuses for being left out. It has to work just as hard as all the other residential schools. Consequently, it has maintained its academic achievement and is consistently in the top fifteen in SPM and above 95% of its students score straight As in the PMR examination. Hence, C1 is one of the top residential schools in Malaysia and the best school in the Selangor district. This entitled the school to be selected to be nominated a school of excellence in 2009.

For the science innovation and engineering competitions in 2010, the school produced two projects. The first was on 'Algae as a bio fuel producer relative to Malaysia' and the second was 'Used cooking oil as biodiesel'. Both projects won only bronze awards due to incomplete research and the fact that they were the school's first attempt in bio-chemistry innovation. Insufficient laboratory instruments in the school were blamed for the insufficient research progress of the subjects searched. In its niche areas, science activities, the school has been actively involved in establishing links with overseas schools. The school has international links with schools in Japan and France in language acquisition and a mutually beneficial link with a local institution on thinking skills, language proficiency and debating skills. The mutual understanding which has been established is hoped to open up more exposure for the students' future undertakings.

6.1.6 School C2

C2 was established in 1973 in a small town in the centre of Malaysia. It is a co-educational school which accommodates 900 students from Form 1 to Form 5. Like the rest of the residential schools in Malaysia, C2 is well-provided with educational facilities and well-funded despite its isolated location. It is well-known for its extra-ordinary performances by its uniformed organisations, its Malay language debating teams and in rugby and mathematics. C2 is unique in that it is the only one of the six selected residential schools to offer engineering subjects to Form 4 students. With engineering options available, students are exposed to engineering skills and are able to sit an engineering paper in their SPM, which provides them with easy access to engineering courses in their future undertakings. Occasionally, C2's students have been given opportunities to exhibit their engineering skills, especially in creating a solar car, solar racing and solar cooking in engineering competitions.

In science innovation and engineering, C2's students have shown their talents by producing many innovations and engineering projects over the years since 2000. They have reached the point of representing Malaysia in the Mathematics Olympiad and in F1*inschools*. Their capabilities in mathematics and engineering cannot be denied. In 2010, C2 was successful in winning a silver medal with its science innovation attempt entitled '*Urena lobata* L. (Caesarweed) as a wound healer'. Research on *Ureta lobata L* took two years to complete after months of struggling with the experiment's procedures, equipment and scientific consent. However, the effort paid off when their curiosity was assisted by collaboration with related government agencies and universities.

On the academic side, C2 does not really shine like the other five schools discussed above. It has been ranked 24th, 35th and 45th out of 55 residential schools respectively in SPM in the three years 2008-2010. Furthermore, the school's high cumulative grade points especially in science subjects (biology, physics and chemistry) show that the students are having internal problems in mastering the subjects being taught to them. This is intriguing, as the school has a long history and enjoys the same standards of student quality as the other residential schools.

Summary

The six schools which participated in this study are examples of the uniqueness of the residential schools in central Malaysia. Being managed by different management teams indirectly influences the students' experiences in learning. It will therefore be interesting to explore the students' responses to science and to try to understand the effects which participation in science research based competitions have on their attitudes towards school science and towards science in general. The overall results gathered from the schools would become a benchmark of the effectiveness of the programme in terms of the uniqueness of the residential schools setting.

6.2 Responses to science amongst the residential schools students in Malaysia

This part of the questionnaire contained 137 statements about science and technology on five aspects of science experience, 'my future work', 'me and the environment', 'my science classes', 'my opinions about science and technology', and 'my out of the science classroom experiences'. The findings are used to indicate the current responses of students in residential schools to science compared with the national data gathered in Malaysia in 2004.

6.2.1 Factor Analysis

Factor analysis was used in the study to identify underlying dimensions or factors that explain correlations among a set of variables. It was employed to discover the basic structure of a domain. It allows the uncovering of the primary independent dimensions such as attitudes to their chosen future job, perceptions of science classes, thoughts on S&T and behaviour towards environmental issues and science experiences outside the classroom. The data collected from a large sample of groups help to identify the structure.

6.2.1.1 'My future job'

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.759
Bartlett's Test of Sphericity	Approx. Chi-Square	1932.85
	df	325
	Sig.	0.00

The responses of the students to the twenty-six statements pertaining to 'my future job' were factor analysed using the Principal Component method and then by a varimax rotation with Kaiser Normalization as practised in Malaysia's ROSE project in 2004. A total of nine factors (initial eigen values exceeding 1.00) which accounted for about 62.8% of the total variance were extracted. The underlying statistical assumptions of factor analysis were tested. A Kaiser-Meyer-Olkin (KMO) measurement produced a value of 0.759, which indicates a fairly good measure of sampling adequacy. In addition, Bartlett's Test of Sphericity was statistically highly significant (χ^2=1932.85; df=325; p-value=0.00). The total variance is explained and the component matrix is shown in Table 8.

Table 8: Factor loadings on 'My future job' in high-achieving students in residential schools in Malaysia

	Component					
	1	2	3	4	Mean	Std. Deviation
15. Working with something I find important and meaningful	.513				3.67	0.615
25. Developing or improving my knowledge and abilities	.560				3.79	0.497
16. Working with something that fits my attitudes and values	.496				3.60	0.692
17. Having lots of time for my family	.498				3.62	0.647
23. Having lots of time for my interests, hobbies and activities	.605				3.21	0.903
19. Working at a place where something new and exciting happens frequently	.655				3.33	0.852
8. Working artistically and creatively in art		.569			2.70	1.097
10. Making, designing or inventing something		.606			3.20	0.917
6. Building or repairing objects using my hands		.611			2.66	1.066
7. Working with machines or tools		.587			2.87	1.066
24. Becoming 'the boss' at my job			.502		2.86	1.092
21. Controlling other people			.694		2.18	1.005
22. Becoming famous			.698		2.20	1.076
3. Working with animals				.449	2.11	0.991
2. Helping other people				.488	3.65	0.632
11. Coming up with new ideas		.430			3.53	0.785
5. Working with something easy and simple					3.14	0.952
4. Working in the area of environmental protection					3.36	0.839
12. Having lots of time for my friends					3.20	0.842
9. Using my talents and abilities	.458				3.67	0.635
20. Earning lots of money	.405				3.48	0.799
13. Making my own decisions					3.32	0.800
14. Working independently of other people					2.96	0.900
18. Working with something that involves a lot of travelling	.449				3.02	0.991
26. Working as part of a team with many people around me	.447				3.58	0.716
1. Working with people rather than things					3.12	0.842

Extraction Method: Principal Component Analysis.

a 4 components extracted.

Table 8 shows the factor loading of the 26 items on each of the nine factors extracted. Only factors with a loading of 0.30 or greater are displayed.

An examination of the factor loadings shows that only three factors have at least three or more items loaded significantly on them. An examination of the contents of the items loaded in these factors indicates the following patterns of factor clustering;

Factor Cluster	My future job	Item references
I	Important, improves knowledge and abilities, lots of free time, and involves something new and challenging	15, 16, 17, 25, 23, 19
II	Artistic, requires creativity and invention, constructive	8, 10, 6, 7
III	Person in charge, able to control people and to be famous	24, 21, 22

Descriptive Statistics

(Appendix G)

The descriptive statistical results indicate that the residential students rated ten out of the thirteen items depicting the respective job characteristics as very important (77%) in their choice of future career. Only two items were rated as not so important and one item (being famous) was rated as not at all important.

Interest profile of Items in Cluster 1

(A job that is important, improves knowledge, provides lots of free time and involves something new and challenging)

Items in this cluster of topics (*see* Table 8) indicate that residential students in the residential schools were most interested in jobs requiring working at something which they find important and meaningful, which involves the development of their knowledge and abilities, which fits with their values and attitudes, which enables them to have lots of time for family and personal activities, and which allows them to work at a place where they can encounter something challenging and exciting.

Compared with the previous data collected from Malaysian students in 2004, the high achievers in this current study have categorised three additional items into this cluster: having lots of time with family, enabling them to enjoy their own activities, and involving them in something which is challenging and exciting. Possible explanations for this ability to identify their own needs in this way are their experiences of being away from their families since they were in Form 1 (12-13 years old) and the managerial skills which they need in coping with another 700 virtual siblings who are sharing the same facilities available in the school. Their independence and their commitment to everyday challenges in a boarding school makes them more appreciative of 'time' and 'family' and gives them a readiness to confront 'challenges'.

Interest profile of Items in Cluster 2

(A job that is artistic, requires creativity and invention, and is constructive)

The statistics and the contents of this cluster of topics indicate that students in the residential schools were interested in jobs which involve artistic ability and creativity in art, inventiveness, design and opportunities to develop new things using their hands and machine tools.

The residential students seemed interested in jobs which related to their own talents and abilities. They therefore fancied something challenging to test their own capability at any task as long as it offers interest and a unique challenge to their creativity. This finding is different from the items in Cluster 2 as gathered in 2004; the respondents in that survey were interested in jobs which meant having lots of time with their families, on personal activities and for mingling with friends. They had high interest in working with something easy and simple, rather than a job which involves something new and exciting.

This finding shows differences in attitudes between the residential students on the direction of their future jobs compared with those of Malaysian students in 2004. The residential students were seeking challenge and self-satisfaction whereas the national students were more concerned with something which is straightforward and less challenging in terms of level of difficulty, yet still satisfying.

Interest profile of Items in Cluster 3

(A job that involves the ability to lead)

The statistics and contents of this cluster of topics suggest that the residential sixteen-year-old students were interested in jobs which would allow them to be the boss, however they were not interested in controlling people and being famous.

All the items found in Cluster 3 were also found in Cluster 4 in the national study except for ‘making lots of money’. This implies that residential students were interested in careers which allow them to be in charge without any intention of controlling others in order to become famous. Their job preference was concentrated on the ability to gain respect and self satisfaction, and money was found not to be the main priority.

Table 9: National vs Residential Students' responses, mean score (SD) and differences in mean score in regard to statements about 'My future job'

My Future Job	Number			95% Confidence Interval for Mean	
		Mean	S.D	Lower	Upper
Residential Schools	362	3.142	0.336	3.107	3.177
Nationwide Data	1581	3.034	0.379	3.016	3.053
Total	**1943**	**3.054**	**0.374**	**3.038**	**3.071**

From ANOVA test; F= 24.638, p-value= 0.000 at 0.05 significant level

From the findings shown in Table 9, it is very obvious that both the residential students and the national students from the earlier survey felt that it is important to have science as their future job, with values of mean=3.142; sd=0.336, and mean=3.034; sd=0.379 respectively. The residential school students placed high value on jobs which offer something they find important and meaningful, involve the development of their knowledge and abilities, fit with their values and attitudes, provide lots of time for family and for personal activities and hobbies, and working in a place at which they can encounter things which challenge and stimulate them. They also wanted jobs which require them to be artistic and creative, involving inventing, designing and developing new things using their hands and machine tools. On the other hand, the national data showed that students in Malaysia were most interested in ‘important and meaningful jobs that help and develop or improve their knowledge’ and are suitable for their attitudes and values. They also thought that it is important to have jobs which will give them ample time for their family and their interests, and which will enable them to work at something easy and simple at a place where new and exciting things happen.

Overall, the residential students scored highly in these items compared with the national students. The ANOVA test showed that there is a statistically significant mean difference between the two types of school in the desire for a future job with a high value of F=24.638 and a p-value=0.000 at 0.05 significant level. With 95% confidence interval of mean score of residential students in future job at (3.107, 3.177) and national students (3.016, 3.053), both indicate interest in science as their future career.

6.2.1.2 ‘Me and the environment’

KMO and Bartlett’s Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.718
Bartlett’s Test of Sphericity	Approx. Chi-Square	709.86
	df	153
	Sig.	0.00

The second part of the questionnaire consisted of eighteen statements pertaining to the topic ‘Me and the Environment’. The responses gathered in 2010 from the residential students on their thoughts about themselves and the environment were factor analysed using the Principle Component method, followed by a varimax rotation with Kaiser Normalization as practised in the ROSE Malaysian Country Project. A total of six factors (initial eigen values exceeded 1.00) which accounted for about 55.2% of the total variance were extracted compared with the ROSE Project in which only five factors were loaded. The underlying statistical assumptions of factor analysis were tested. The Kaiser-Meyer-Olkin (KMO) measurement had a value of 0.718, indicating a fairly good measure of sampling adequacy. In addition, Bartlett's Test of Sphericity was statistically highly significant (χ^2 =709.86; df=153; p-value=0.00). The total variance is explained and a component matrix is shown in Table 10.

Table 10: Factors loadings for 'Me and the environment' in high-achieving students in residential schools in Malaysia

	Component					
	1	2	3	4	Mean	Std Deviation
10. People should care more about protection of the environment	.593				3.76	0.579
7. We can still find solutions to our environmental problems	.633				3.59	0.701
12. I think each of us can make a significant contribution to environmental protection	.538				3.64	0.657
15. Animals should have the same right to life as people	.475				3.30	0.973
18. The natural world is sacred and should be left in peace	.558				3.47	0.766
5. I am willing to have environmental problems solved even if this means sacrificing many goods	.553				3.00	0.939
17. Nearly all human activity is damaging for the environment	.511				3.23	0.894
14. I am optimistic about the future	.551				3.24	0.888
8. People worry too much about environmental problems		.464			2.35	1.127
1. Threats to the environment are not my business		.546			1.47	0.875
11. It is the responsibility of the rich countries to solve the environmental problems of the world		.578			2.57	1.156
13. Environmental problems should be left to the experts		.664			1.70	0.941
4. Science and technology can solve all environmental problems		.461			2.87	0.971
2. Environmental problems make the future of the world look bleak and hopeless			.540		3.54	0.880
3. Environmental problems are exaggerated			.612		2.90	1.036
9. Environmental problems can be solved without big changes in our way of living		.		.602	2.32	1.127
6. I can personally influence what happens with the environment	.434	.325			2.77	0.944
16. It is right to use animals in medical experiments if this can save human lives	.303				2.75	1.062

Extraction Method: Principal Component Analysis.

a 6 components extracted.

Table 10 shows the factor loading of the eighteen items on each of the six factors extracted. Only factors with a loading of 0.30 or greater are displayed.

An examination of the factor loadings shows that only three factors have two or more items loaded significantly on them. An examination of the contents of the items loaded in these factors indicates the following patterns of factor clustering;

Factor Cluster	Me and the Environment	Item references
I	Environmental protection, animal rights and responsibilities towards maintaining it	10, 7, 12, 15, 18, 5, 14, 17
II	Indifference to environmental issues, optimism and solving environmental problems	8, 1, 11, 13, 4
III	Environmental issues are exaggerated and this makes the world hopeless	2, 3

Descriptive Statistics

(Appendix G)

The descriptive statistics results indicate that the residential students were very positive towards environmental protection and animal rights. They rated ten out of fifteen items as very important (67%); 'people should care more about protection of the environment', 'we can still find solutions to our environment problems' or 'make a significant contribution to environmental protection'. They agreed (13.3%) with 'have environmental problems solved even if this means sacrificing many goods', and 'science and technology can solve all environmental problems'. They (20%) strongly disagreed on 'people worry too much on about environmental problems', 'threats to the environment are not my business' and 'environmental problems should be left to the experts'.

Interest Profile of Items in Cluster 1

(Environmental protection, animal rights and responsibilities towards maintaining the environment)

The statistics and contents of this cluster of topics suggest that the residential students were very positive towards environmental protection and animal rights. They agreed that "human activities are the main source of pollution in the world" and that "everyone needs to be responsible for protecting it".

Furthermore, they were willing to contribute to the betterment of the environment and believed that animals have the same rights as humans and believed optimistically about their future. These results closely match the items clustered by the national data in 2004 except for the addition of 'I am willing to have environmental problems solved even if this means sacrificing many goods' and 'Nearly all human activity is damaging for the environment'.

In the curriculum in Malaysia, environment awareness is a part of the school syllabus and is taught across all subjects. Additional information from the media plays an equal role in exposing students to up-to-date information on the current issues pertaining to the environment. As a result, data on the same exposure and experiences were gathered from both groups, resulting in the same opinions in clustering these factors. Both groups appear to be clear and positive about their responsibility and their readiness for protecting their own environment.

Interest profile of Items Cluster 2

(Indifference to environmental issues, optimism and solving environmental problems)

The statistics and contents of this cluster of topics indicate that the residential school students agreed on the statements that 'People worry too much about the environment', 'Threats to the environment are not my business' but 'the responsibility of rich countries', scientists and 'the experts'. Previously in the national data, the items were clustered in two different clusters (three and four). Indirectly, dividing the same items into two reflects their pattern of thinking. They weighed the issues differently compared with the residential students who incorporated the important issues of the environment together with the suggestions for remedying them. Therefore, clustering the items together indicates that the residential students were well exposed to and aware of both the consequences of environmental problems and the capabilities of scientists to address them via the latest media updates on current environmental issues. This understanding subsequently gave rise to the idea of putting the remedial actions into the hands of environmental and science and technology experts.

Interest profile of Items Cluster 3

(Environmental issues are exaggerated and make the future of the world look hopeless)

The statistics and contents of this cluster of topics strongly agreed that ‘environmental problems are exaggerated’ which ‘makes the future of world look bleak and hopeless’. It is interesting that the items were clustered in this way. It implies that they acknowledged the importance of environmental issues and blamed the exaggeration for being responsible for the overall seemingly bleak and hopeless future for the world.

Table 11: National vs Residential Students' responses, mean score* (SD) and differences in mean score to statements about 'Me and the Environment'

Me and the Environment	**Number**			**95% Confidence Interval for Mean**	
		Mean	S.D	Lower	Upper
Residential Schools	360	2.816	0.372	2.778	2.855
Nationwide Data	1577	2.640	0.395	2.621	2.660
Total	**1937**	**2.673**	**0.397**	**2.656**	**2.690**

From ANOVA test; F=59.259, p-value= 0.000 at 0.05 significant level

From the statistics shown in Table 11, it is very obvious that both the residential students and the national students felt that there was an important relationship between them and the environment, with values of mean=2.816; sd=0.372, and mean=2.640; sd=0.395 respectively. Generally, the residential students had high scores for the entire item compared with the national students. Both groups of students felt strongly about environmental protection and animal rights. They agreed that human activities are the main source of pollution in the world and that everyone needs to be responsible for protecting it. They were willing to contribute to the betterment of the environment and they also thought that animals have the same rights as humans.

The Anova test showed a statistically significant mean difference between the residential and the national students in their attitude to the environment with a high value of F=59.259 and a p-value=0.000 at 0.05 significant level. The 95% confidence interval of mean score of residential students in their future career was (2.778, 2.855) and for national students (2.621, 2.660), both indicating interest in the science environment.

6.2.1.3 'My science classes'

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.867
Bartlett's Test of Sphericity	Approx. Chi-Square	1707.11
	df	120
	Sig.	0.00

The third part of the questionnaire consisted of sixteen statements pertaining to the topic 'my science classes'. The responses of the residential students in the data acquired for this current study towards their science classes were factor analysed using the Principle Component method and this was followed by a varimax rotation with Kaiser Normalization as practised in the ROSE Malaysian Country Project. A total of three factors (initial eigen values exceeding 1.00) which accounted about 52.1% of the total variance were extracted. The underlying statistical assumptions of factor analysis were tested. A KMO measurement showed a value of 0.867, indicating high sampling adequacy. In addition, Bartlett's Test of Sphericity was statistically highly significant (χ^2 =1707.11; df=120; p-value=0.00). The total variance is explained and a component matrix is shown in Table 12.

Table 12: Factor loadings on 'My science classes' in high-achieving students in residential schools in Malaysia

	Component			Mean	Std. Deviation
	1	2	3		
13. School science has taught me how to take better care of my health	.680	.343		3.61	0.664
7. The things that I learn in science at school will be helpful in my everyday life	.742			3.66	0.366
11. School science has increased my appreciation of nature	.596	.360		3.56	0.681
6. I think everybody should learn science at school	.514			3.45	0.883
8. I think that the science I learn at school will improve my career chances	.693			3.65	0.685
10. School science has increased my curiosity about things we cannot yet explain	.558	.393		3.48	0.735
4. School science has opened my eyes to new and exciting jobs	.681			3.57	0.690
12. School science has shown me the importance of science for our way of living	.672			3.57	0.678
3. School science is rather easy for me to learn	.493			2.82	0.925
2. School science is interesting	.637			3.53	0.716
5. I like school science better than most other subjects	.568			2.91	0.981
15. I would like to have as much science as possible at school	.664			2.63	1.037
1. School science is a difficult subject		.551	.478	2.37	1.030
9. School science has made me more critical and sceptical			.572	2.78	1.032
16. I would like to get a job in technology	.326		.580	3.00	1.075
14. I would like to become a scientist	.456			2.34	1.126

Table 12 show the factor loading of sixteen items on each of the three factors extracted. Only factors with loadings of 0.30 or greater are displayed.

An examination of the factor loadings shows that only three factors had two or more items loaded significantly on them. However, there is an interesting item which was found to be unique which clustered singly in Cluster 2. An examination of the contents of the items loaded in these factors indicates the following patterns of factor clustering;

Factor Cluster	My science classes	Item references
I	Functional values of school science and interest in science learning	13, 7, 11, 6, 8, 10, 4, 12,3, 5, 15,2
II	Science is a difficult subject	1
III	Being critical and having an interest in science and technology jobs	9, 16

Descriptive Statistics

(Appendix G)

The descriptive statistics results indicate that the Malaysian residential students were very positive towards school science. They (80%) strongly agreed on twelve out of fifteen items including; ‘school science has taught me how to take better care of my health’, ‘the things I learn in science at school will be helpful in my everyday life’, ‘school science has increased my appreciation of nature’ and ‘school science has increased my curiosity about things we cannot yet explain’. They agreed on 3 items; ‘school science is rather easy for me to learn’, ‘science is a difficult subject’ and ‘school science has made me more critical and sceptical. They strongly disagreed on 1 item; ‘I would like to become a scientist’.

Interest Profile of Items in Cluster 1

(Functional values of school science and interest in science learning)

The statistics and contents of this cluster of topics show that the residential school students were very positive towards school science. They believed that science learned at school was helpful in their everyday lives, taught them to take better care of their health, increased their appreciation of nature, and was interesting to learn. Furthermore, they also agreed that science classes should be learned by everyone, improve career chances, stimulate curiosity and show their importance in daily life. They also added that they enjoyed science more than most other subjects and would like to have as much science in school as possible. Most of the items in ‘My science classes’ were clustered in Cluster 1, which was different from the findings in 2004.

This indicates that the residential students were very positive towards their science classes in school. They found that they referred to their science classes as a source of informative knowledge, catering to their inquisitive natures and opening their eyes to natural phenomena. They weighted all the items as equally important to them.

Interest Profile of Items in Cluster 2

(Science is a difficult subject)

The statistics and content of this cluster of topics showed that the residential school students expressed disagreement on ‘science as a difficult subject’. No other item was associated with it. It turned out to be a strong statement. With a mean of 2.37, the students disagreed over the statement that ‘science is a difficult subject’, and this was the same mean as was collected in 2004. This shows that ‘science’ is not perceived as a difficult subject by either type of Malaysian student.

However, looking at the percentage of responses given by the students, there are bipolar responses, especially on ‘I would like to have as much science as possible at school’, ‘school science is a difficult subject’ and ‘I would like to become a scientist’. This reveals mixed perceptions amongst the students on their agreement to the statements, indicating varied science learning experiences in the classrooms and the difficulties of various science subjects.

Interest Profile of Items in Cluster 3

(Being critical and being interested in jobs in science and technology)

The statistics and contents of this cluster of topics indicate that the residential students agreed that science had made them more critical and sceptical, which increased their interest in jobs related to technology. Being trained to be critical in the subject, the residential students were attracted to jobs related to science and technology.

Table 13: National vs Residential Students' responses, mean score* (SD) and differences in mean score in responses to statements about 'My science classes'

My science classes	Number			95% Confidence Interval for Mean	
		Mean	S.D	Lower	Upper
Residential Schools	359	3.006	0.484	2.956	3.057
Nationwide Data	1574	2.933	0.5771	2.904	2.961
Total	**1933**	**2.946**	**0.562**	**2.921**	**2.971**

From ANOVA test; F=5.063, p-value= 0.025 at 0.05 significant level

From Table 13, it is very obvious that both the residential students and the national students realised the importance of school science with values of mean=3.006; sd=0.484, and mean=2.933; sd=0.5771 respectively. Generally, the residential students rated highly for the entire item compared with the national students. Both groups of students felt that it was important to them that school science was helpful in their everyday lives, taught them to take better care of their health, increased their appreciation of nature, and was interesting to learn. Furthermore, the residential students also agreed that science classes should be learned by everyone, improve career chances, stimulate curiosity and show their importance in daily life. They also added that they enjoyed science more than most other subjects and would like to have as much as science in school as possible. This was because of its capability to stimulate critical thinking in the subject and its influence on them to consider jobs in technology.

From the ANOVA test, there was no significant mean difference between the two groups, with a low value of F=5.063 and a p-value=0.025 at 0.05 significant level. The 95% confidence interval of mean score of the residential students in their attitude to their science classes was (2.956, 3.057) and of national students was (2.904, 2.961). This indicates that both groups agreed on the positive influence of their science classes on them.

These findings also indicate that Malaysia's centralised education system successfully provides equal science experiences across the different school systems. As a result, it gives the same exposure to and emphasis on the particular areas which resulted in these equal responses.

6.2.1.4 My opinions about science and technology

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.86
Bartlett's Test of Sphericity	Approx. Chi-Square	1627.93
	df	120
	Sig.	0.00

The fourth part of the questionnaire consisted of sixteen statements pertaining to 'My opinions about science and technology'. The responses of the residential students in the data acquired for this study in 2010 towards their opinions about science and technology were factor analysed using the Principle Component method and then by varimax rotation with Kaiser Normalization as practised in the ROSE Malaysian Country Project. A total of four factors (initial eigen values exceeding 1.00) which accounted for about 59.4% of the total variance were extracted. The underlying statistical assumptions of factor analysis were tested. The KMO measurement had a value of 0.858, indicating a high measure of sampling adequacy. In addition, Bartlett's Test of Sphericity was statistically highly significant (χ^2 =11627.93; df=120; p-value=0.00). The total variance is explained and a component matrix is shown in Table 14.

Table 14: Factors loadings on the topic 'My opinions of science and technology' in high-achieving students in residential schools in Malaysia

	Component				Mean	Std. Deviation
	1	2	3	4		
1. Science and technology are important for society	.687				3.70	0.638
3. Thanks to science and technology, there will be greater opportunities for future generations	.744				3.72	0.620
2. Science and technology will find cures for diseases such as HIV/AIDS, cancer, and so on.	.683				3.74	0.563
4. Science and technology make our lives healthier, easier and more comfortable	.727				3.64	0.646
5. New technologies will make work more interesting	.697				3.66	0.701
11. A country needs science and technology to become developed	.628		.338		3.59	0.643
6. The benefits of science are greater than the harmful effects it could have	.529				3.10	0.884
7. Science and technology will help to eradicate poverty and famine in the world	.525				3.05	0.870
8. Science and technology can solve nearly all problems	.617				2.95	0.921
9. Science and technology are helping the poor	.477	.378			2.68	0.997
12. Science and technology benefit mainly the developed countries	.580		.344		3.45	0.73
13. Scientists follow the scientific method that always leads them to correct answers	.550				3.20	0.821
14. We should always trust what scientists have to say	.310	.660			2.77	0.933
15. Scientists are neutral and objective	.507	.479			2.28	1.001
16. Scientific theories develop and change all the time	.398			.668	3.14	0.878
10. Science and technology are the cause of environmental problems	.284	.314	.354	.421	2.77	0.994

Extraction Method: Principal Component Analysis.

Table 14 shows the factor loading of the sixteen items on each of the four factors extracted. Only factors with loadings of 0.30 or greater are displayed.

An examination of the factor loadings shows that there were only two factors which had two or more items loaded significantly on them. An examination of the contents of the items loaded in these factors indicates the following patterns of factor clustering;

Factor Cluster	My opinions about science and technology	Item references
I	Kudos, benefit and perceptions of science and scientists	1, 3, 2, 4, 5,11,6, 7, 8, 12, 13, 15
II	Unstable knowledge and most misused	16, 10

Descriptive Statistics

(Appendix G)

The item statistics and contents of this cluster of topics show that the residential students had very positive attitudes towards S&T. They agreed strongly that 'S&T are important for society', giving credit to S&T for 'finding cures to diseases such as HIV/AIDS, cancer, etc', 'making our lives healthier, easier and more comfortable' and making 'work more interesting'. However they disagreed on the item 'Scientists are neutral and objective'.

Interest Profile of Items in Cluster 1

(Kudos, benefit and perceptions of science and scientists)

The statistics and contents of this cluster of topics show that the residential school students were very positive towards science and technology. They believed that science and technology are important to society, are able to find 'cures for diseases such as HIV/AIDS', cancer and so on', 'makes our lives healthier, easier and more comfortable', 'wealthier' and 'beneficial for the nation's development'. They collectively agreed that scientists are people who work systematically, are neutral and are objective in their work. As many as 81% of the items were grouped in the same cluster. This shows that the residential school students believed in the capability of science and technology to benefit society, bring better health, increase national wealth and generate a positive way of life. Although the items were grouped differently compared with the 2004 findings, the new cluster is believed to be due to the residential school system itself which emphasises the science and technology culture in the school ambience. The students were enriched by their awareness of current issues in science and technology and had ample access to the latest information which allowed them to contribute fully in science and technology discussions.

Interest Profile of Items in Cluster 2

(Unstable knowledge also misused)

The statistics and contents of this cluster of topics show that the residential school students agreed that science is unstable knowledge as it changes all the time and they blamed science and technology for environmental problems. This cluster is exactly the same as the data gathered in 2004. As both sets of students relied on the same media available in Malaysia, it is not unexpected that they had similar exposure to and input on science and technology and subsequently came up with the same judgement on the issues discussed.

Table 15: National vs Residential Students' responses, mean score* (SD) and differences in mean score to statements about 'My opinions about science and technology'

My opinions about science and technology	**Number**			**95% Confidence Interval for Mean**	
		Mean	S.D	Lower	Upper
Residential Schools	357	3.120	0.439	3.075	3.166
Nationwide Data	1570	2.860	0.429	2.838	2.881
Total	**1927**	**2.908**	**0.4424**	**2.888**	**2.928**

From ANOVA test; F=106.281, p-value= 0.000 at 0.05 significant level

From Table 15, it is very obvious that both the residential students and the national students agreed on the role played by science and technology with values of mean=3.120; sd=0.439, and mean=2.860; sd=0.429 respectively. Generally, the residential students rated high for the entire item compared with the national students. Both groups of students felt that science and technology is important in providing good health, wealth, safety and stability for a nation.

They acknowledged that scientists play positive roles and also the consequences of this.

From the ANOVA test, there was a statistically significant mean difference between the residential and the national students over their opinions about science and technology with a high value of F=106.281 and a p-value=0.000 at 0.05 significant level. The 95% confidence interval of mean scores of the residential students (3.074, 3.166) and the national students (2.8387, 2.881) indicated that both acknowledged the importance of science and technology.

6.2.1.5 My out of the science classroom experiences

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.83
Bartlett's Test of Sphericity	Approx. Chi-Square	2478.13
	df	253
	Sig.	0.00

The fifth part of the questionnaire consisted of 61 statements pertaining to 'my out of the science classroom experiences'. The responses of the residential students gathered in 2010 about their out-of-school experiences were factor analysed using the Principle Component method and this was followed by a varimax rotation with Kaiser Normalization as practised in the ROSE Malaysian Country Project. A total of five factors (initial eigen values exceeding 1.00) which accounted about 55.1% of the total variance were extracted compared with ROSE Project in which fourteen factors were loaded. The underlying statistical assumptions of factor analysis were tested. The KMO measurement had a value of 0.832, indicating a high measure of sampling adequacy. In addition, Bartlett's Test of Sphericity was statistically highly significant (χ^2 =2478.13; df=253; p-value=0.00). The total variance is explained and a component matrix is shown in Table 16.

Table 16: Factor loadings on 'My out of the science classroom experiences' of high-achieving students in residential schools in Malaysia

	Component					Mean	Std. Deviation
	1	2	3	4	5		
39. Changed or fixed electric bulbs or fuses	**.586**				.377	2.45	1.074
40. Connected an electric lead to a plug etc.	**.490**				.450	2.76	1.113
60. Used tools such as a saw, screwdriver or hammer	**.543**				.383	3.00	0.900
52. Opened a device (radio, watch, computer, telephone, etc.) to find out how it works	**.398**		.326	.338		3.03	1.080
22. Made a fire from charcoal or wood	**.593**					2.50	1.040
21. Put up a tent or shelter	**.629**					2.71	0.969
14. Collected edible berries, fruits, mushrooms or plants	**.570**					2.19	1.081
23. Prepared food over a campfire, open fire or stove burner	**.607**					2.63	1.020
25. Cleaned and bandaged a wound	**.549**					2.79	0.970
17. Planted seeds and watched them grow	**.517**		.369			2.60	1.004
5. Collected different stones or shells	**.460**		.333			2.49	1.036
59. Mended a bicycle tube	**.485**					2.15	1.067
50. Sent or received e-mail	.435	**.614**				3.46	0.912
49. Downloaded music from the internet	.383	**.628**				3.48	0.921
46. Searched the internet for information	.407	**.689**				3.69	0.660
51. Used a word processor on the computer	.361	**.460**		.346		3.25	0.924
47. Played computer games	.348	**.595**				3.54	0.831
44. Used a mobile phone		**.702**				3.73	0.656
45. Sent or received an SMS (text message on mobile phone)	.315	**.667**				3.71	0.694
48. Used a dictionary, encyclopaedia, etc. on a computer	.415	.402	**.468**			3.40	0.829
32. Made a bow and arrow, slingshot, catapult or boomerang	.358			**.434**		1.78	0.970
16. Participated in fishing	.402					2.09	1.140
61. Charged a car battery	.388					1.72	1.038

Extraction Method: Principal Component Analysis.

a 5 components extracted.

Table 16 shows the factor loading of the 60 items on each of the five factors extracted. Only factors with loadings of 0.30 or greater are displayed.

An examination of the factor loadings shows that only two factors had two or more items loaded significantly on them. An examination of the contents of the items loaded in these factors indicates the following patterns of factor clustering;

Factor Cluster	My out of the science classroom experiences	Item references
I	Household fixes and repairs and outdoor and nature activities	39, 40, 60, 52, 22, 21, 14, 23, 25, 17, 5,59
II	Latest communication and technologies	50,51, 49, 46, 47, 44, 45

Descriptive Statistics

(Appendix G)

The descriptive statistics results indicate that the residential students rated fourteen out of the eighteen items clustered as 44% most often performed (activities related to ICT), and 33% as often performed activities. However, two items were rated as seldom performed actives; 'made a fire from charcoal or wood' and 'collected different stones or shells', while another two items were classified as never performed; 'collected edible berries, fruits, mushroom or plants' and 'mended a bicycle tube'.

Interest profile of Items in Cluster 1

(Household fixes and repairs and outdoor and nature activities)

The first cluster of out-of-school activities showed that the residential boy students were often doing household fixes and repairs especially on electrical items (2.58) and were often involved in outdoor and nature activities (2.58). However the girls were found to be seldom involved in doing household chores (2.20) and participating in outdoor activities (2.34). For Malaysian students, these simple and basic chores are formally taught to them in their living skills and science classes. Outdoor activities were enjoyed by the residential students only during out-of-school activities such as camping, jungle trekking and mountain climbing. Therefore, these two types of activity, domestic and action, were mostly enjoyed by them during their limited out-of-school hours.

The factor analysis showed that the residential students seldom took part in farm-related activities such as ‘collecting edible leaves, fruits, mushrooms or plants' and 'collecting different stones or shells'. They were also found seldom to have the chance to do house chores such as changing or fixing electric bulbs or fuses, and mending a bicycle tube.

Interest profile of Items in Cluster 2

(Latest communication and technologies)

The second cluster of out-of-school activities is related to the high use of the latest communication technologies such as mobile phones, the internet and computers. The students frequently used the latest communication technologies, a result similar to the data collected in 2004.

Table 17: National vs Residential Students' responses mean score* (SD) and differences in mean scores of statements about 'My out of the science classroom experiences'

My out-of-school experiences	**Number**			**95% Confidence Interval for Mean**	
		Mean	S.D	Lower	Upper
Residential Schools	359	2.678	0.428	2.634	2.726
Nationwide Data	1570	2.502	0.447	2.480	2.524
Total	**1929**	**2.535**	**0.4469**	**2.515**	**2.555**

From ANOVA test; F= 46.218, p-value= 0.000 at 0.005 significant level

From the data shown in Table 17, it is very obvious that both the residential students and the national students acknowledged the importance of their out-of-school experiences as shown by the values of mean=2.678; sd=0.4284, and mean=2.5024; sd=0.4447 respectively. Generally, the residential students produced higher scores for all items compared with the national students.

The ANOVA test showed that there was a statistically significant mean difference between the residential and the national students in their out-of-school experiences with a low value of F=46.218 and a p-value=0.000 at 0.05 significance level. The 95% confidence interval of the mean scores of the residential students to the national students in their out-of-school experiences was (2.634, 2.722) and (2.480. 2.524). This shows that both groups found interest in their out-of-school experiences but that there were different levels of interest due to time restrictions, location and the logistics of living in a school hostel as opposed to living at home.

6.2.2 A comparison with the data from sixteen-year-old Malaysia students in national schools in 2004

The factor analysis of the data gathered from Malaysian non-residential national school students in 2004 and from residential students in 2010 shows some differences and some similarities (Yoong, 2005). Through the statistical analysis, some significant differences between the two groups have emerged. This is especially true in those sections which involve students' opinions. The students in residential school were found to know and to show their strong opinions especially in the four topic areas 'my future job', 'me and the environment', 'my opinions of science and technology' and 'my out of the science classroom experiences'. Because they were both subject to the centralised school system and curriculum, both groups understandably showed equal attitudes towards 'my science classes'.

i. 'My future job'

Students in both groups intended to work in a job which they perceived to be important and meaningful and which was suited to their values and abilities. However, being in the group of the nation's high achievers with access to the best facilities and knowledge available, the residential students aimed at jobs which are more challenging, more stimulating and potentially able to provide recognition in terms of dignity and respect. They were also found to be looking for jobs which would appreciate their creativity and ideas for inventing and designing something new. At the same time, they wanted jobs which would enable them to have ample time to be with their families and to spend on their personal interests. This is probably a consequence of the long periods of separation and the challenges which they face while they are away at boarding school.

On the other hand, the general, non-residential Malaysian students aspired to jobs which would be equally challenging and stimulating but easy and simple and which would enable them to earn more money. The findings of the current study are consistent with those of Crites (1969) who suggested that students are interested in careers in which they have confidence. With the exposure residential students had, the more influenced they will be towards it (Colbeck *et al*., 2000).

ii. 'Me and the environment'

The residential students showed more positive appreciation of maintaining the environment and devising remedial actions to solve environmental issues. They were aware of the latest environmental issues and they recognised the important role played by scientists and environmental experts in dealing with these issues. They were also aware of the high costs of restoring, maintaining and correcting environmental imbalances. Interestingly, they gave equal weight to these issues, meaning that they understood the impact of environmental issues and the importance of remedial actions. These were not found in the national data, since the non-residential students had evaluated the issues differently, although they did recognise two issues; damage to the environment and the need to restore it. The residential school students definitely had higher attitudes in regard to 'me and the environment' compared with the national students surveyed in 2004.

iii. 'My opinions of science and technology'

In terms of their opinions of science and technology, the residential students had high regard for the roles of science and technology and of scientists in their daily life. They believed strongly in the potential of science and technology to provide harmony in terms of health, safety, stability, wealth and peace towards the country. They trusted and respected the role of scientists in their respective niches.

With 357 samples compared with the 1570 samples who participated in the national study, only two major clusters emerged among the residential students compared with four in the national study. This implies that there was a significant difference in attitudes towards science and technology between the two groups. The residential students had collective positive ideas about the benefits which science and technology provide for life compared with the range of ideas held by the national students.

iv. 'My out of the science classroom activities'

Staying in a school hostel for most of the year, the residential students had definitely restricted access to out-of-school activities. They were found to be actively involved in activities involving the latest telecommunication innovations and technologies. This was the same as the data collected from non-residential students in 2004.

The residential schools students were found to be seldom involved in activities which involved household chores and outdoor activities. Only the boys' schools had frequent exposure in those areas. They also had little experience of farming and activities which involved physical gadgets. The national students, however, who have more time outside the school compound, had better experience in many out-of-school activities such as farm-related activities, using physical instruments and physical gadgets, models and science kits (Yoong & Ayob, 2004).

In summary, there were not many differences identified between the two groups of students, however, those which were identified were very meaningful in highlighting the attributes which contribute to attitudes towards science amongst the residential students and Malaysian students as a whole. Furthermore, there is no difference of science response amongst the types of residential schools or gender involved. The residential school students were found to have higher attitudes towards science and scientists compared with the national students. This is perhaps a consequence of the different school settings and the input given by the residential school authorities and is possibly enhanced by the students' own positive attitudes towards learning.

6.3 The impact of SRBCs on students' responses to school science and science in general

This section is divided into two parts. The first part (6.3.1) explores the views of contestants on science research based competitions (SRBCs) in relation to their responses towards school science. Their experiences and views were gathered from interviews and from their students' diaries. The findings were categorised under five themes; science learning, working with peers, learning from experts, working under pressure within school constraints and taking up careers in science. The second part (6.3.2) considers students' responses towards science in general during their participation in competitions, and students' responses are discussed in two identified areas; interest in science and research activities, and interest in science issues.

This classification is tailored to the theoretical framework shown in Figure 2 and gathered themes from the responses made by the students.

The data were gathered from the questionnaire, from interviews with eleven students who had taken part in SRBCs and from diary entries made by seven participants. Analysis of the data showed that there were more apparent similarities found between schools than differences, so this section presents the consolidated feelings and common source of the similarities and then considers the differences at the conclusion of each theme. Despite the initial superficial positiveness in most of the aspects studied, deeper analysis of the students' comments shows that there were also less positive aspects in the students' responses. As the data were drawn from a series of case studies of six schools, the discussion will be initially based on the schools and then generalised into more significant factors which emerged from the study.

6.3.1 The impact of SRBCs on students' responses towards school science

This section reports the students' experiences of SRBCs in building and sustaining their responses towards school science. The issue is discussed under five major themes; learning science, working with peers, learning from experts, working under pressure within school constraints, and taking up a career in science. Their gathered responses are significantly related to the four gathered impacts of students' science learning development shown in Figure 2; learning school science, careers in science, image of science, and values of S&T. Although not much mentioned in the context of the image of science, the students developed an understanding of who scientists are and how they work in real life.

6.3.1.1 Learning science

Participating in high-level research competitions which specifically involve science and engineering requires a lot of investigation, reading, deep understanding of particularly interesting areas and experimentation. These challenges are particularly tough for inexperienced young researchers. Because they are young and have not been able to acquire formal research skills and have a limited source of reliable content knowledge, the participants have to engage with and cope with large amounts of information and data from a wide range of accessible sources. Some of them acquire the relevant information from their teachers, their parents, the internet or books, and some make contact with experts in the appropriate field. Therefore, it is interesting to understand their perception of the knowledge which they gain, the interest which they develop and the learning experience which their participation gives them.

School science research projects require students to become involved in various science areas within a restricted time frame. Teachers who regularly work with groups participating in SRBCs have reported that a well-researched and well-developed science research project for a competition normally takes more than a year to develop. By participating, the students are exposed to large amounts of unwritten curriculum in addition to what they experience in the classroom. The value-added experience and the challenges which they encounter are still under-researched and need to be understood in order for educators to maximise the time, the potential of the programme, the level of interest and the advancement of school science learning.

From the interviews and the students' diaries, four main areas emerged and the views of contestants in SRBCs on learning science in school can be categorised into these four themes;

i. overall learning experience
ii. understanding science content
iii. self-efficacy towards science learning
iv. practical laboratory experience.

i. Overall learning experience

Being able to experience and test the science knowledge which they acquire outside the formal science classroom lets students play with the variables in order to understand the consequences of actions and react to the outcome. From the information gathered, unconscious learning via first-hand experience was regarded as meaningful and enjoyable by the participants. A participant from school B1 made a clear comment on how the hands-on activities had brought extra meaning to his learning experience:

> "Before this, I just studied. But after participating in this competition I can really apply what I have learned in class. This was made possible with the help of the information I got during the programme. And that means a lot to me. As for example for the recent project, I can really apply my biology and chemistry knowledge in the research. It makes the learning experience a joyful one and meaningful too". (B1, 28-32)

With his several years of involvement in science research projects, this student was aware of the positive impact which participation had had on his science learning experience. This is encouraging, as the subject taught in the classroom is only partially related, or even not related at all, to the subject researched. From the interviews, four sub-themes emerged supporting the view of participants that their science learning is related to their overall experience of learning science; it is meaningful and enjoyable, there is repeated content knowledge, the application of the content, and the opportunity for practical experience.

The practicality and applicability of the learning which is assimilated by participants during the process of preparing for competitions brings meaning to science learning. It brings life to the science learned in the classroom and it is motivational in that it brings joy and added meaning to the participants' overall understanding of the subject. Because it is meaningful, it increases their confidence and motivates them to want to go further in the science stream. This is much aligned with Colbeck *et al.*'s (2000) findings on how hands-on activities and adequate exposure increase students' interest and motivation for science learning compared with passive learning. The opinion quoted above was supported by a participant in co-educational school C2:

> "... science is natural phenomena. I am curious about it but I don't want to do research in depth ... just use the existing science and play with it". (C2, 80-81)

In her opinion, science seems to be something which is enjoyable and exciting. The belief that it is something 'to play with' is an indicator of her perception of the subject particularly as something to experiment with the variables and with the freedom to explore more. Therefore, interest in a particular science research project was found to be driven by inquiry and by the problem-solving challenge of the subject and the challenging research process involved. Allowing inquisitive minds to explore more about something which is new excites the development of participants' interest and sharpens their scientific and project management skills. This view was further confirmed by a girl from school G2:

> "… this research give us more interest in the subject but not really in our academic area". (G2, P2, 126-129)

Strength of interest and persistence in doing science research activities result from the enjoyment of new experiences and the realisation that science is meaningful. However, the interest remains primarily on 'open' science investigation activities and does not really transfer into conventional school science subjects. From the information gathered, this is probably due to the type of knowledge which is acquired and the excitement involved in contrast to the science taught in the classroom. The same student continued:

> "... plus it widens our perspectives, we are able to look at certain things in a new way. Especially in bio-technology". (G2, P2, 131-132)

and her school-mates agreed:

> "... although it really didn't contribute to my academic work, I really appreciate the skills and technique of doing things scientifically". (G2, P3, 128-129)

> "... it satisfies our curiosity and thirst for exploring new things". (G2, P1, 130)

The students' responses showed that their interest in learning science was stimulated by the freedom to explore and the ability to learn new science areas which the competitions provide. The rich learning engagements had brought a meaningful and exciting learning experience to the participants, and this initiated integration between commitment and motivation towards positive science learning. This finding is in agreement with the findings of Wallace (1996), Paris (1998) and Osborne and Collins (2000) which showed that students are into autonomous learning. With autonomous learning, they are more positive in learning school science.

ii. Understanding science content

Participating in scientific and engineering research projects enables students to acquire strong background knowledge in particular areas. This is essential in order to allow them to manipulate the variables. Some of the topics involved in the research areas had been taught in the classroom while others were completely new to the students. When they encountered something new in the pure science discipline, the participants needed to employ a variety of methods to acquire sufficient content knowledge. They had to seek sources for their scientific content background, using the internet, books and journals and attending extra classes in other established research institutions. The content knowledge which they gain can be applied in two ways; by supporting the research and by enabling them to make better sense of the subject or topic in their classroom learning. The repetition of their content knowledge acquired in the classroom and in the research laboratory helped some of the participants towards more meaningful understanding of the science lessons which they learned in class. This was underlined by the responses given by the participants, for example:

> "Upon starting with the project, we were zero in chemistry; after following classes in university and doing practical work in the university's laboratory, we actually understood the application of chemistry and what is Mol, and stuff which our teacher in school tried to teach us in the classroom". (G2, 45-48)

This comment suggests that school science is easier to understand after participating in SRBCs because of the variety of applications of science knowledge used in preparing for the competitions. The participants benefited from their experiences and believed that participation was very helpful in enabling them to understand difficult concepts taught in the classroom. Hands-on experience and conceptual learning were the main secret ingredients here. Unfortunately, the positive impacts were closely restricted to the specific area researched. This issue was also raised by other participants in different schools. Although participation brought understanding of a particular subject, it remained only in that specific research area and did not transfer to other science topics and to unrelated science subjects.

> "... in class, it doesn't really affect much."(C2, 40-41)

> "Maybe it only gives some impact to some subject ... not to all, as what we did was all about oil, and in Form 5 we learned about the subject, but not all. Furthermore, we also learned about alcohol and we did our research on both areas, so it is just a repetition ... but not for all of the subjects". (C1, 102-106)

In the comment above, participant C1 repeatedly used the phrase 'not all'. He strongly emphasised the limitations of the topics and the knowledge learned through the research in terms of its applicability to his science learning in the classroom. The enhancement of topics learned in the classroom was much appreciated when it was related to the research topics. This context-based learning made a significant contribution to science understanding and students' attitudes to science (Bennett *et al*., 2006). Accordingly, the application of the research-based knowledge in day-to-day situations led to a better understanding and increased students' confidence in that particular topic.

> "Yes, by entering the competition, we are exposed to lots of projects and it uses lots of physics concepts. And this actually helps me to understand science better than in the classroom". (G2, P3, 25-27)

From this response, it is clear that participating in science research activities permits participants to explore specific science areas which have nothing much to do with mastering the science content in their science classroom yet still enriching them with extra science input.

iii. Increased self efficacy in science learning

Being actively involved in science research, participants are given an extra platform to explore their interest with minimum guidance from their mentors and teachers. They are granted the freedom to design projects, test the results and analyse their findings. Their original ideas about doing scientific experiments change after they have involved themselves directly in their projects. Science experiments are no longer restricted to confirming science findings but become an act of curiosity to find the truth behind a natural phenomenon. This was confirmed by a conversation between two participants from G2:

> P2: "We got A+ for our chemistry in the recent examination.
> P1: At first we really had no confidence in it.
> P1: We took only a few practical [activities] to really understand and able to calculate correctly.
> P1 & P2: We really enjoy learning through practical work then theory in classroom. It is better to have the exposure in the university beforehand, then we will understand the subject better." (G2, P1 & P2, 51-56)

Undertaking research for competitions demands a serious focus on findings which are likely to make a useful contribution to the existing science findings and have good potential to be materialised and marketable. Accordingly, with the new learning environment that they have experienced and the challenges which they have faced, participants acquire the ability to apply that knowledge and confidence to their changed self-abilities. These findings further support the idea of Schneider *et al.* (2002) that giving students experience which incorporates hands-on/minds-on science with the goal of scientific knowledge allows them to use the scientific inquiry and higher order thinking skills through the exploration of real-world issues. This too builds their self-confidence in science. Consequently, their positive self-confidence develops into greater self-efficacy in the subject.

iv. Practical laboratory experience

Research projects engaged the students in this study in a series of practical experiences. These involved long hours of laboratory and field work and gave them experience of carrying out their own experiments according to their research questions and early assumptions; this had enabled the students to think, plan and react to the results gathered independently and without conventional supervision. This thinking and experimenting provided a meaningful learning experience which made science learning for them easier and much more interesting.

> "The students can learn new things that they can't do in the classroom. I know CMS, I can study the chemical compounds in plants and that is interesting to me. For me, I am a practical person not an analytical person; it suits me better to learn science this way. It always feels good to learn science this way. I really appreciate the knowledge now. If I have the chance, I would just love to do more research in the future." (B2, P2, 23-28)

> "Not only that, while doing the experiment and playing with all the variables, it helps me to understand physics better as we have to design the experiment." (G2, P3, 27-29)

The learning process through independent exploration turned out to be more interesting and meaningful for the participants. Although it is clear that it did not have much impact on all science subjects, even so it stimulated their positive interest in science in general. They did not mention anything about instructions that they had to follow, but repeatedly mentioned the excitement of being able to play with variables. Being in charge of their own learning seemed to be the main attraction for them to carry on with the work. While playing with the variables and with different ideas, they seemed to grasp the particular subject easily. None of the participants complained about being bored or about difficulties which they faced while trying to understand the subjects which they were researching.

> "... do it first then learn it in class is more interesting and easier to understand as we can relate it." (C1, P1 & P2, 49-50)

> "... we took only a few practical [activities] to really understand and be able to calculate correctly. We really enjoy learning through practical work than through theory in the classroom"
> (G2, P1, P2, 52-53)

Their attitude towards learning science through hands-on activities is unquestionable as they emphasized it repeatedly during the interviews.

> "Science is interesting through practical work, not via theory".
> (G2, P1, P2, P3, 78-79)

Scientific skills are a part of the skills acquired in science learning. They are taught formally in classrooms and laboratories, and are tested in schools and by national examinations. Through investigating and confirming hypotheses, participants in SRBCs were involved in designing, preparing and conducting experiments related to their field of research. Their ventures involved several experiments and were carefully guided by their teachers and mentors and by experts in the relevant field. All of the competitions have their own rules and regulations to guide the participants. These regulations act as a guideline which explicitly explains the what-can-do and the what-not-to-do in experimental work. This allows the students to gain from scientific opportunities and to explore them with more confidence. There are no set answers or predictable results for any of the experiments done, and this creates a very open-ended exploration for the participants and enables them to appreciate the sound findings which they make about science and nature.

The participants regarded the intensive practice as a beneficial exposure which had directly improved their skills in following experimental procedures in class and their attitudes towards science.

"The preparation I did before starting any experiments helped me to increase my science process skills in class. Especially on how to do the experiment and on how to play with the variables and to communicate well with the data collected." (G2, P3, 30-33)

"Our mentors were there to supervise us so we had to do the experiments carefully. Actually, we are only doing preparation for the experiments. We had to do buffers to extract the brain. But we had to it properly anyway and take the correct readings of the chemicals. Since our mentors were there, we didn't have any chance to cheat anyway. From there, we learn to be HONEST. Without that honesty, our project might not even work in the end. So we are required to be honest at any cost". (G2, P1:2/4-7)

Their perspective on the need to conduct a proper scientific investigation developed with time. A dialogue between participants in G2 showed how significant the exposure was for them, especially in conducting science experiments. They valued honesty, accuracy in calculation, the need for repeated experiments, and safety precautions:

P1: "They [mentors] taught us to do experiment with HONESTY.
P2: Which we never really practise in the school laboratory.
P1: We also learned the need to be honest in reporting and calculating as it might jeopardize the end result and [lead to] repeated experiments.
P2: We also learned about safety precautions, and that is crucial!
P1: Especially when we handle the enzyme, it will be denatured". (G2, P1 and P2, 58-63)

Similar to the statements made by these G2 students, participants in C1 had the same opinion about the significance of the experience, especially when dealing with variables and values:

> “For me, in doing research, we performed lots of science experiments with all the steps required in order to find the right measurable evidences. Indirectly, we were taught how to play with the variables”.
>
> (C1, P3, 92-95)

Awareness of specific scientific skills and values is important not only when dealing with research but also for answering Paper 3. The ability to calculate and manipulate variables would be advantage for the participants. On top of that, experience in designing experiments and collecting data from the manipulated variables gave them more confidence in conducting their own research.

> “It also helped me in my Paper 3. The preparation I did before starting any experiments helped me to increase my science process skills in class. Especially on how to do the experiment and on how to play with the variables and to communicate well with the data collected”. (G2, P3, 30)

> “Actually while carrying out the research we are actually practising our skills in Paper 3. Only that, it is longer. So right now, it becomes so easy for me to do Paper 3 and I am aware what and how to anticipate with the experiment, especially with the procedure, and how to do it”. (C1, P3, 97-101)

A participant in G2 repeatedly emphasized the significance of her experiences in SRBCs to her capabilities in applying the skills she had learned. This was the case not only in her research area (physics) but also in the other science papers:

> “I have more confidence in my Paper 3 after participating in the competitions. Not only in physics but also in biology and chemistry too. This is all because of the techniques (skills) that are being put on us.” (G2, P3, 34-36)

Every experiment conducted in science involves report writing, which is regarded as the most crucial part of science research. To the majority of students it is the most complicated task. Without exception it was regarded as a big obstacle by the participants too. With their involvement in the science research competitions, two of the participants who were in Form 4 commented on the positive impact of it on reporting the findings of science experiments:

> "We have improved a lot, as before this we didn't know how to write a report". (C1, P2, 61)

> "Yes, … we hadn't learned about it before this; we learned the skills before we actually learned how to do it in class. As we started the project in early Form 4, we hadn't learned anything much yet. Furthermore, we learned this thing first before we learned it in class". (C1, P1, 62-65)

> "We can help others on how to write a report and do the experiment in class by ourselves. It enables us to use the exact words for reporting too". (C2, P2, 42-44)

From the responses quoted above, Form 4 SRBC participants had benefited considerably from their experience in reporting on experiments. Being new in the science stream, participation was an opportunity for them to practise intensively the correct form of science report writing. Nevertheless, none of the Form 5 participants made any comment on report writing. This was perhaps due to the year of experience they had had since they were in Form 4.

Across the case study schools as a whole, the findings point to participation in SRBCs being beneficial to the participants' science learning. However, the individual case studies revealed differences between schools:

i. Only girls schools and girls in co-educational schools thought that school science learning is enjoyable and can be applied in research projects and *vice versa*. They admitted that school science which is related to the researched areas was easier to understand as it is being repeatedly explained in the classroom or applied during the research.

In comparison, the boys in the boys schools did not make any association or comments about how exciting and meaningful schools science turned out to be after they had participated in an SRBC. They fancied exploring engineering projects instead of science innovation projects. Therefore, they were more interested in research which is different from what they have learned in the classroom. Having the opportunity to challenge themselves with something new had given them more confidence. This in turn had increased their self-efficacy towards science learning.

Indirectly, the enjoyment and relevance of learning science after they had participated in competitions was associated with the choice of research topic in which they were involved. The more related it was to the school syllabus, the more relevant and enjoyable it became. This was a consequence of the application of the subject learned in the classrooms, whereas venturing into something which is totally new would give them self-efficacy towards science learning.

ii. Participants in schools G2, C1 and B2 agreed that practical learning in the research project made science learning in class easier. These were the Form 4 students, who were new to the science stream and had not been previously involved in or exposed to practical science in school. Being new to practical science, their early involvement in SRBCs made their science learning easier, especially in report writing. Only those participants who had been carrying out most of their practical work and research in the university mentioned the interesting impact of practical experiments on them. The experienced participants who were in Form 5, however, agreed on their improved awareness of experimental procedures and skills in answering Paper 3 after being involving in intensive science research competitions.

In summary, therefore, despite the initial superficial similarities, deeper analysis of the students' comments shows that there was not much in common between the schools studied. The positive impacts on science learning (especially on experimental skills) were much related to the level of exposure and the scale of the scientific projects in which they were involved during the preparation of science research rather than on their schools or on the types of school. The more exposure and experience they had, the easier, more interesting and more beneficial the scientific skills became which could be applied in their science classrooms. All in all, the students showed unquestioned development of interest after their experience in learning school science.

6.3.1.2 Working with peers

From the interviews and the students' diaries, three main areas were identified which were associated with the experiences students gained while working with peers when they had participated in SRBCs, and these will be discussed next.

i. Project management

Working in groups seemed to be enjoyed by participants. By working as a team, they felt secure and more confident. In teams, they were able to support each other while they were dealing with obstacles and challenges. Thus, with competitions such as SRBCs which are well known as prestigious and demanding programmes, a good partnership is important. The presence of partners lightens the burden and shares the responsibilities. Furthermore it provides extra hands for preparing experiments and conducting research, particularly as the submission date approaches.

> " ... basically Halida and I were doing things together since Form 2; I found that we can really work together well so that's why we got into the group … mostly we participated just because of interest". (G2, P1, 8-10)

> "I learned that the experiment is easier to conduct if there are many helpers". (G1, P1: 4/34-35)

Effective collaboration between team members helps the growth of the project. It allows work delegation especially in assigning specific responsibilities between the members. This enables them to exchange views and passions and to expand their curiosity together. Thus, only the trusted, talented and able-to-get-along friends will be invited to join a team. Group work was claimed by one participant in B2 to have been the best experience he had ever had:

> "Working in a group, we know how to exchange views and it brings the best experience ever". (B2, P2, 31-32)

Staying together in boarding schools enriched the students' lives with the presence of many peers, comfort and affection. They were trained to support each other in every aspect of their lives. While they were working together, participants in G2 believed that they appreciated their friends' presence and contributions more. The experiences and the endurance gained in exploring the particular subject resulted in increased motivation and confidence for them. This finding accords with that of Pine (1999), that group settings encourage students in developing their cognitive change. Their collaboration directly proved the positive meaning of 'team work' which is stated in the school science syllabus and gave extra meaning to good communication skills and tolerance. These were regarded as significant experiences by participants from three different schools:

> P2: "we understand our friend better,
> P1: … and tolerate each other better;
> P3: working alone is tiring, and we really need help from other friends". (G2, P1, P2, P3, 134-136)

Interest in science research remains the major factor which had attracted students to the programme. As a matter of a fact, the support of friends turned out to be the essential factor which gave them overall satisfaction. This can be observed from the students' responses when they were asked about their motivation for wanting to participate in competitions:

> "Interest, and one of the other driving factors is because of friends' motivations". (C2, P1, 11-12)

and P1 in G1 also emphasised this in her diary in week 1, when she was still struggling to identify issues for her research topic:

> "A bit stressful by myself, however friends are very helpful". (G1, P1: 3/3-4, wk1)

The chemistry of working together helped them to face and encounter all the challenges together. As mentioned by Head in 1985, the attitude of peers has a strong influence on a student's interest. There are some significant benefits shared between team members; they are able to communicate effectively on the same shared issues, they are better at finding problem-solving solutions, they have greater confidence in the methods used and they become more tolerant of one another.

In summary, working with peers in SRBCs instilled a team spirit among the members. The selection of a team mate was initially based on the presence of a chemistry between individuals over the capability of working intensively together, and secondly by having the same passions about the subject areas. Working in teams encouraged them to undertake the research and explore related areas widely. Working in teams is relevant because of the limited time allocation and because it can involve students with the same interests in a particular area. In return, they develop their confidence in science learning and learn how to be capable of performing research independently.

It can therefore be concluded that participating in SRBCs is beneficial to participants' social skills and team-building spirit. However, there were some small differences identified between schools. Some of the benefits were found to be related to particular factors:

i. Girls in the girls schools enjoyed working with peers on their science projects more that students in the other two types of school. They felt more confident and comforted when they were surrounded by their peers. The peer-support system in the schools works very well in this regard. When working with peers, they believed that they were able to exchange knowledge, and to share problems and excitement together. This was precisely the opposite with the boys; they did not mention anything about the working with peers in the interviews. Nevertheless, they appreciated the presence of 'helpers' instead of peers. This emerged in C2's interviews.

ii. The group-leaders in G2 and B2 perceived that a science project is best experienced with the presence of peers. Having been long associated with SRBCs, they perceived that the students gained more confidence about pursuing science when they were working with peers.

iii. Interestingly, the more experienced participants pointed out that with the presence of peers, the research turned out to be more interesting. To them this was linked with the ability for them to communicate with each other. With communication, they understood the project better and were able to plan for the advancement of the project together.

In conclusion, the opportunity to work with peers was found to be adding a positive impact to the participants. It allowed them to have experience of working as a team, to communicate better and to be able to share and delegate their work in accordance with the time frame. Although it was not clearly stated that the particular characteristics of the peers they preferred to be with were important to them, it could nevertheless be easily concluded that it has to do with selecting peers who share the same passions in science research activities as they do. This can be regarded as true since they appreciated the help, the motivation and the quality chat sessions which they were able to have with their peers.

6.3.1.3 Learning from experts

From the interviews and the students' diaries, three main areas were identified which were associated with the experiences they had of learning from experts in their particular field when they participated in SRBCs. Experts here are defined as people who are experts in the particular relevant area. They were the ones who managed, developed and monitored the students' projects from the beginning until the completion. These experts might be teachers or external advisors from universities or other institutions. They therefore form the students' images and perceptions of people who work in science areas.

i. Content knowledge

> "I really treasure the knowledge that I gained from the professor".
> (B2, P2, 33)

The opportunity to work on subjects which have attracted their curiosity with experts brings considerable meaningful experience to participants especially when it involves new and previously unknown areas of science. Those who had had opportunities to work collaboratively with external advisors claimed that it was the best experience they ever had during SRBCs. From the statements given by some B2 students, they were excited, and they were grateful for the skills, knowledge and know-how that they gained far more than they had been within the school environment. The most remarkable moments for them were when they were able to experience intensive laboratory work and benefit from the knowledge that they had acquired in their research. This was confirmed by a conversation between two participants from G2:

> P1: "It helps us to understand biology and chemistry better.

P2: Yes, this is because we are working on creating an environmental kit using the mud fish's brain components. We learn what are enzymes, its function, coenzyme and chemical structure that help it to stimulate other functions.
P1: We learned about enzymes beforehand, so we got to understand more.
P2: Upon starting the project, we were zero in chemistry, after following classes in university and doing practical work in university, we actually understood the application of chemistry and what is Mol, and stuff that our teacher in school tried to teach us in classroom.
P1: We are now better". (G2, P1 and P2, 40-53)

From this response, it is clear that being able to acquire extra knowledge from a trusted figure [an expert] develops their building of knowledge in the particular subject and at the same time encourages their interest in the area.

The interest which the participants develop is due to the satisfied feeling after participating actively in such meaningful activities. Consequently, trust and confidence develop interest amongst the participants. This can be seen from the statements made by students in G2 and G1:

"... that is why we need to collaborate more with the universities, as they make it interesting somehow". (G2, P1, 120-121)

"We got some motivation from our teacher on starting our project. We were very happy and excited to start our first research".
(G1, P1: 3/12-13, week 1)

"We started to have more interest in bio-tech. As we know bio-tech is also a part of innovation. So we decided to learn more about bio-tech from Ammerlia's sister, Nazeera, to help with our research". (G1, P1: 4/12-14, week 1)

This student in G1 stated clearly in her diary entry about her developing interest in bio-technology after being introduced to it by her teacher. These students were motivated and excited to be involved with something new. The enthusiasm for venturing into something new with the guidance of a trusted figure seems significant in deepening their interest into some aspects of science.

ii. Managing the projects

During the mentoring of the projects, the students were not only guided in their research but also introduced to other areas related to the research. For various reasons, the participants were asked to attend extra classes in a university or in other institutions. Appropriate guidance by the experts provided them with a deeper understanding of the topic they were studying. In this way, they eventually came to know how to manage the research by themselves and to plan what steps were needed to follow up their curiosity.

> "They are also students, so we can relate to new things while working with them". (G2, P2, 122)

> "It is better to have the exposure in the university before and then we will understand the subject better". (G2, P1, P2, 54-55)

> "My mentors were absolute darlings and gave us proper instructions and guidance". (G2, P1: 3/38, week 1)

> "Our advisor helped a lot by giving extra info on tannin and the method of extracting the chemical compound".
> (G1, P1: 3/9-10, week 1)

The student in G1 whose diary is quoted above continued to write about her positive impression of her advisor in week 4. She said:

"Our advisor is very kind and caring. She said that scientists never give up. Always repeat the experiment until it works".

(G1, P1: 3/55-56, week 4)

With their strong content knowledge and scientific skills, they become more confident with themselves and with the project. Therefore, their attitudes towards the subject studied increased and their belief in their capability in science grew.

Teachers play a big role in mediating the students' projects with related institutions. From the students' point of view, some of the teachers had been very cooperative and committed in supporting them with all the facilities needed.

"We would like to thank our teacher for her commitment, she bore with us every day, sending us to universities and all. She was so wonderful and never let us down with her time, effort and kindness". (G2, P1, P2, P3, 137-139)

"Our teacher was a very helpful and important component in the competition". (C1, P2, 148)

"Our teacher was very responsible; he would normally inform us early". (B2, P1, 18)

"Our advisor helped us to do the experiment". (G1: 3/25, week 2)

However, there were also some teachers who were regarded as irresponsible by their students:

"The most problematic [thing] was the last minute information from the teacher. The facilities were difficult to get, as we had to rely on the teachers". (B1, P1, 52)

P2: “There were times when we are free, but not our teacher [mentor]”.

Her friend from the same school then added:

P1: “We really needed them [teachers], as we need to use the laptop for research. And we were free only on night time. That was our major problem”. (C2, P1, 110-111)

“Not all teachers understand what we are doing”. (C2, P2, 106)

“We agree to open to all, but we don’t have enough mentors in school”. (G2, P1, 119)

From the statements collected, there were some teachers who were not able to help their students due to other commitments. This is not surprising as teachers in schools have many responsibilities. They have to teach, to monitor students’ activities and carry out other activities which are related to students’ academic performance. As mentoring SRBCs demands a lot of their attention out of school hours, not many teachers are willing to sacrifice their family time to be with their students. This situation is worsened if the school administration only permits the project to be done after the normal school hours. So with not enough personnel and facilities, they tend to look outside for external help. However, relying on external help sometimes brings unpredictable situations when the experts have their own reasons for not being able to continue to facilitate a project. This was experienced by participants in C2:

“Our mentor [external advisor] quit at the last minute when we were waiting for his result on the plant’s chemical component analysis. We were so upset and we had to find another mentor who could help us to analyse the chemical compound in our research project. Due to this, we had to delay our project for another three months and alter the project accordingly".

(C2, P1, 112-115)

And after two months, they still had the same problem with another external supervisor. This was clearly stated in a diary entry by one of the C2 students:

> "Still waiting for UKM to give their result on the chemical composition". (C2, P2: 3/51, week 3)

The problem continued:

> "Received no result from UKM yet. I feel the pressure and nervous because I have started nothing with the project".
>
> (C2, P2: 3/81-82, week 5)

This continued until week six, which was only two days before the competition:

> "Just received the results from UKM. We got positive feedback". (C2, P2: 3/93, week 6).

Thankfully, with the results that were achieved, this student was successful and was awarded silver in the competition. It turned out to be a real treat which was worth waiting for after such a long period of trial and misery.

iii. Interest in science and technology

Not much was discussed or said by the participants about their research activities in their schools. Most of the participants were more excited about sharing the experience and research which they had done with their external mentors rather than with their teachers. They seemed to value science and technology more with exposure outside school. With that attitude, the participants appeared to develop their interest in science and technology according to the amount of exposure they had. The more exposure they had, the more their interest in science and technology developed. Consequently, their comments on experiencing research with experts reflect their thoughts on the values of science and technology to them.

One G2 student said in her interview:

> "The research they [experts] are doing is actually new to our country and I am into it too. Well, let see what will happen later". (G2, P2, 87-88)

With the help of the experts, the students were more aware of the value of science and technology and anything that contributes to it. Working with the experts outside the school seemed to be extremely motivational for them; especially towards the completion of the project.

> "At first, we didn't understand the project at all, especially with all the chemistry terms and all. We didn't have much confidence in the project but after our mentor gave us some spirit and encouragement that the project will be simple and insyaAllah a winning project, both me and Haleeda were determined to go through the weeks to come". (G2, P1, 3/5-8)

This attitude was confirmed by another participant in school G1, who wrote in her diary:

> "But we didn't quit and never gave up on searching. We kept contact with our former senior Kak Nazurah and she advised us to search for another theme. Well we think that is the best way". (G1, P1: 2/27-29, week 2)

However, not all the experiences with external experts went well. There were also some who had left a negative impression with the participants.

> "A researcher told us that he couldn't help us with the experiment of using rats and processed the extract into cream at the very last minute. He gave us lots of not sensible reasons such as 'for the sake of security purposes', it doesn't make any sense right?".
>
> (C2, P2: 1/46-48, week 2)

This response led to disillusion:

> "I could not stand the feedback I got this week. It made me give up and want to stop the experiment." (C2, P2: 4/46-47 week 2)

With endurance and persistence to complete the task, they moved on with the support of their teachers and their efforts won them a silver medal. The lesson well learned by them is that 'a quitter will never win any race'.

From the responses quoted above from the interviews and from notes taken from the diaries, it is clear that on the whole the SRBC participants had benefited considerably from their experience of working with their internal and external experts. It had increased their positive image of science and added science and technology values to them. Of the six schools chosen for the study, only four had experienced working with external help. Students in G2 experienced comprehensive research help from their external mentor in the university's laboratories and classes, C2 and G1 students experienced a short consultation on the chemical components of a researched plant from a university upon the completion of their whole project, and B2 had received appropriate guidance from a government research agency on related issues which involved environmental issues and pollution in Malaysia. Most of them had looked outside for help due to insufficient facilities in the schools and the fact that they were involved in high levels of science research. The schools that benefited only from the involvement of internal mentors enjoyed the guidance of their internal experts and work in school's laboratories.

This study has produced results which corroborate the findings of a great deal of the previous work in this field. As mentioned by Schibeci (1984), Weinburgh

(1995), Osborne and Collins (2001), TRS (2008), Barmby *et al.*, (2008) and Bennett and Hogarth (2009), teachers are the main actors in influencing and determining students' attitudes in science. From the analysis of the data, there are some points that were highlighted:

i. Students in both of the girls-only schools claimed that they had developed their interest in the subject which they studied with the help of their internal and external mentors. They also appreciated the help from their internal mentors (their teachers). According to them, their teachers gave them full attention, help and guidance on completing the study. Their teachers' commitment was highly appreciated and was regarded by the students as very helpful to them.

ii. Nevertheless, there were also comments about their teachers' and their external mentors' other commitments; one C2 student was not satisfied with her teacher's time management. In addition to that problem, she also had an unreliable external adviser who turned her down after being involved with the project for several months. This happened towards the end, causing delays to their project due to lack of access to facilities. Because of this, this student had to skip some classes to ensure that she would be able to finish her experiments and type the report while her teacher was still in school, and she changed the objective of the project according to the limited results gathered. One of the boys in B1 had problems with a teacher who liked to do things at the last minute. This student claimed that he was not told about the details of the competition until the last minute, which resulting in him producing an incomplete research project. Therefore, a mentor's role and commitment played a big role in the students' attitudes towards their capabilities on the accomplishment of a project.

iii. Students in G2 and C2 believed that having external mentors helped them to expand their knowledge especially in their research areas, which in turn brought about a positive motivation towards the projects. On the other hand, G1 students admitted that they were motivated by their internal mentors and one B2 student was satisfied with the expert's advice on the content of the project.

To sum up, the levels of the participants' gratitude for the role played by mentors were found to vary according to the level of involvement they had. The more time and contacts they made, the more motivation and knowledge they gained on the particular subject. Being new to research, they had high levels of appreciation of the help which they received and they appreciated the commitment given by their mentors to ensure the success of their projects.

6.3.1.4 Working under pressure within school constraints

From the interviews and the students' diaries, three main areas were identified which were associated with having to work within project constraints when they had participated in SRBCs, and these are discussed next.

i. Demands

Participating in the most prestigious science competitions was regarded as an honour and a privilege by students in all of the schools. Being selected to participate not only gave them an opportunity to explore beyond everyone else in their class, but was also a recognition of their talent and capabilities in science research. This is due to the long hours of research, the demanding experiments and the inventiveness which the research activities require. Therefore, only the most capable and talented students who are interested are selected to be in the school team.

From the students' points of view, the responsibility made real demands on their attention and time. This was especially true for those who were participating for the first time, that is, the students in C2, G1 and B1.

> P1: “We are very worried as we are in Form 5 and the exam is just around the corner, and we also involved in the Police cadets, prefects ... but we are really interested and that drives us forward.
>
> P2: I have been thinking about quitting along the way, but when I think back that my teacher is ready [to help me] and so is my team mate ... and that makes me get moving ... I have no other option”. (C2, P1 and P2, 28-33)

> “Problems: managing time for experiment, classes and self study. Limited time because I started late. I have to skip classes. Some of my teachers are mad with me for skipping their classes. No assistance to lend a hand for my project.” (B1, P1: 1/100-105, week 6)

> “We felt motivated and sometimes pressure occurred inside us because we had a packed schedule in the school, so we didn’t have enough time. We were at the eleventh hour!”
> (G1, P1: 3/ 50-52, week 3)

From the information gathered, the main concern for the participants was the sacrifices they had to make to their academic classes. Another factor that worried them was the obligation towards many activities at the same time. Some of them focused on the nearest deadline one at a time, but some pushed themselves to do everything that they were responsible for all at the same time.

> “We can’t miss our classes either, with additional classes in the afternoon and marching in the evening, it is a hectic schedule for us actually”. (C2, P1, 107-108)

> “I faced difficulties in searching for any free time to discuss with my teacher and my partner. I have marching practice, homework and responsibility as head girl”. (C2, P1: 1/29-31, week1)

> “We didn’t go to the University of Putra this week because there is simply no TIME. It’s English Drama week and we have to be fully focused. So technically, we didn’t even do much research and there wasn’t even much progress in our work”. (G2, P1: 1/56-59, week 3)

This resulted in panic, frustration and stress amongst the participants.

> “We were so afraid that we couldn’t finish it before time”. (C2, P1: 3/114, week 7)

> “We are not rushing. Then again, we need to be extra careful and detailed in doing experiments to ensure there is no error”. (G1 P1: 4/55-57, week 4)

> “The post-graduate student who assisted us couldn’t be around over the weekends, so we are afraid that our project’s schedules can’t go accordingly as planned”. (G2, P1: 1/34-36, week1)

> “I cried although I know it is useless and I called my parents to seek for comfort and wise words”. (C2, P1: 2/46-47, week 2)

> “I became stressed with the activities and it made me focus less on the project”. (C2, P1: 4/63-64, week 4)

The stress, panic and frustrations were mostly recorded in their diary entries during the preparation weeks; only one of them mentioned her stress during the interview. This suggests that they had met the challenges wisely and had totally forgotten about it; amazingly none of them quit the competition due to the pressure and challenges encountered.

The other obvious remark made was on time management and the school’s restriction on the research activities.

ii. Restrictions

Being students in boarding schools, the participants were tied up with well-programmed activities and fixed-schedule routines. They did not have much choice of free time or the freedom to carry out their own activities. Consequently, different schools came up with various styles of managing students' time according to their judgement and the overall school perspective. For instance, the participants who came from schools which regarded science research as their niche areas and had positive thoughts about their students' potential in science, such as G2, C1 and B2, were allowed to carry out their research right after the school hours, from 3pm until the evening. Others were granted permission to carry out their experiments and research during school hours and to be away from school in order to carry out their research in universities and other research agencies. However, in the other three schools, students were permitted to carry on with their research between 3pm and 6pm on school days and from 10am to 6pm during the weekends.

> "The time-table was too packed – R&D, class, homework, tuition. I am getting MAD". (G2, P3: 1/44-45, week 1)

> "I have marching practice and at the same time, I had difficulties in managing my time between the preparation of both competition (marching and science innovation) with homework and the student's problems as I am a head girl". (C2, P2: 1/51-55, week 3)

She then wrote of the same worries in week 4:

> "I faced difficulties again with time management. This time, dance practice has been added to my activities. With me living in a boarding school, it's hard to find free time".
>
> (C2, P2: 1/63-66, week 4).

Due to the restrictions of time and too many activities, the participants had put some priority on the nearest competition deadlines.

> "I focused on the marching and dance practice rather than the project of science innovation because the date of the marching competition and dance show were around the corner". (C2, P2: 2/63-66, week 4)

> "We were in hurry preparing our display board for our presentation. And not to forget, preparing our speech. We really need to find time as we have many school activities during this whole week. Thinking about the presentation sometimes make us feel scared as we both have one kind of problem that is 'EXTREMELY NERVOUS'; hahaha what bad luck". (G1, P1: 1/80-85, week 6)

The benefit of having time constraints is to train the students in the value of prioritising. In order to accomplish everything, they need to have good working time management and planning. Nevertheless, this is an added pressure on the participants as they have to put a lot of effort into many areas without being able to focus on and excel in one. And considering that there are about ten small SRB competitions all year round, it must take a lot of students' and teachers' time to keep updating their preparations for each of the competitions.

With the increases in the competitions' standards and in the numbers of competitors in SRBCs, the higher the standard of research involved. In order to comply with the standard set, participants tend to do research beyond the school syllabus which in return demands better research facilities and consultations from the experts. Some schools have set up a memorandum of understanding (MOU) with specific universities for specific collaborations. The selected universities will help the students to carry out their respective areas of research in their laboratories and offer free consultations and research facilities.

With the help of universities and other research agencies, the students had wider exposure to the research areas which they were interested in but had to rely on the availability of the experts. This resulted in some delays in the procedure, access to facilities and the availability of help.

> "Still waiting for UKM to give their result on the chemical composition". (C2,P1: 51)

> "Internet breakdown and they are doing some maintenance to the computer laboratory. Need to ask my parents to send me a Doogle". (G2, P3: 1/49-50, week 2)

> "Our mentor asked us to come on Wednesday to get more things done like the kit development and all that. So we missed about 2.5 days of classes which added up more things to the existing pile of homework". (G2, P1: 1/67-68, week 4)

In summary, the selection of students to participate in SRBCs is made on the basis of students who have high potential and independence. These qualities are considered as essential for strategic planning, as they need to face many obstacles through the year in order to complete some of the obligatory school missions. They also have to be good in their academic area, in leadership, in creativity and in time management. Along the way, they students in this study had developed skills which are not only related to scientific ability but also to communication, leadership, self-discipline and determination.

The restrictions which were laid in front them were taken as a part of the challenge. They admitted their worries especially in their studies as they were responsible for meeting other school commitments. However, it is also a pity when the same students have to participate in various activities at the same time. This is probably due to the student's capability of carrying out their responsibilities with minimum supervision, and the fact that they are already seen as talented or perhaps reliable and creative in their teacher's eyes. They obviously had positive responses, as can be seen from their diary entries; they always had plans about how to overcome the obstacles they encountered each week. However, their talent in science was not really tested because they were already A-star students who were participating just because the competitions are prestigious and each school needs to win. The question here is, is it worth choosing A-star students to participate and then putting many restrictions on their sacrifices?

From the responses quoted and noted from their communications with the researcher, these SRBC participants had experienced a considerable amount in terms of restrictions and demands from higher authorities. Thankfully, towards the end, they managed to overcome all the obstacles and none of them turned out to be a quitter.

Participating in SRBCs can be a long-awaited experience for some of the participants. To be selected to take part in the most prestigious competitions is a mark of the recognition of their talents, credibility and independence, in addition to their science achievements. This is not only because of the science research challenges but also the thrill of being in the longest and most demanding programme in the school. According to the schools, there are a few points to be observed on the pressures and the demands which students go through along the process:

i. Most of the schools participating expressed their worries about the students' progress due to the time restrictions and the levels of concentration which the projects demand from them. School C1, however, was different. Students in that school did not complain about any of these things in their diaries or in the interviews. The reason for this is that they were satisfied with the preparation time because they were allowed two months off attending their normal classes. This was considered a privilege as not many of the participants enjoyed such an allowance by their school authorities.

ii. Schools which rely on experts in universities for the results of their students' experiments were particularly worried about the analysis of chemical components by external agencies. Having no control over the time or the procedure, the participants had to put up with the time taken to process the analysis.

iii. Both of the girls schools admitted that their students needed to find time to complete their science projects. The projects were challenging for them due to the time frame given to finish the projects, the time allowed for experiments and the limited facilities available in their schools.

iv. Generally there were two different views among the participants. The experienced participants were much disturbed by the time limitations and the limited facilities available in their schools, whereas the inexperienced group were not at all affected by those factors. This was due to the levels of experience which they had and the different awareness of the levels of research and innovation which they needed to reach.

All in all, involvement in competitions has its own pressures and demands. In SRBCs, the pressure is due to two main reasons; the preparation time and the facilities available in schools are insufficient for students to be able to carry out deeper investigations. Being responsible for winning the competitions is another challenge the students have to bear. This was expressed well by a participant from B2:

> "Knowing this prestigious competition is the most difficult thing to do and commit to. Previously this school has been known for interesting projects and for continuously winning first place, so the pressure and the burden is very heavy for anyone to volunteer.
> Our friends are afraid of not being able to come up with interesting project and to win in each competition". (G2, P2, 15-20)

6.3.1.5 Taking up a science-related career

From the interviews and the students' diaries, two main areas were identified which were associated with the intention to pursue a career in science when they had participated in SRBCs, and these will be discussed next.

i. Promotion and motivation

As residential school students, all the participants in this study had been exposed to many science and technology issues, current news and career choices. This was confirmed by the quantitative analysis of the responses to the questionnaire administered in advance. They had higher attitudes to science and were interested in science- and technology-related careers. However, as one of the main objectives of SRBCs is to increase awareness of science and technology among students, it is therefore worth considering what the participants thought was the impact of the competitions in promoting and motivating them into science and technology.

Most of the participants were high achievers in their respective schools. Almost all of them had already set their ambition since they were quite young. For the girls, the main intention was to be a medical doctor, while the boys were more interested in engineering jobs. These ambitions were identified from comments made by the students during the interviews:

> "I have wanted to be anaesthetist since I was small, but I am inspired by the professor and scientist in the laboratory". (G2, P2, 86-88)

> "My ambition has always been somewhere in medicine but now actually I believe I can be a scientist". (G2, P1, 84-85)

> "Yes, while doing it, it opened up my mind that ... why don't I join pharmacy and others [science fields]?" (C2, P2, 56-57)

All these responses were gathered from girls from G2 and C2. Initially, they were attracted to medicine but they had mixed feelings after participating in SRBCs. Although medicine is also a subset of science, it is focused more on health rather than nature and the environment. The introduction of research in science which is incorporated in the competitions had been an eye-opener for the participants into real science research areas. In other words, it promoted what science is all about. Their experiences had successfully created a positive impetus to their initial ambitions – but will it last or is it just an impulsive effect which they have yet to study?

> "For me, after undergoing this competition ... I have been rethinking joining bio-technology instead of medicine. But my father disapproved of it. So I have to put it aside for a while". (C2, P1, 54-56)

The motivation towards science and technology was obvious among the participants. It promoted science and gave them confidence in their abilities towards science and technology. As a result of their increased confidence, they were looking forward to pursuing science further.

> "I want to be an inventor. It has been there since I was young. These competitions really help to increase my confidence and motivate me to go further". (G2, P3, 82-83)

Interestingly, the participants who gave these comments came from schools that had external supervisors for their students. It would interesting to find out the motivation among those who did not have any external assistance.

ii. Impact on future career planning

The common aim shared by the organisers of SRBCs is to promote science careers among the participants. Participants from C1 and G2 had benefited from the experience by reconsidering their initial ambition into something related to science and research.

"For me, before I participated in this competition, I was not looking forward to furthering my career in science, especially medicine. I was more into engineering. But when I thought it over, this field is not that difficult and I am sure that it is not impossible to proceed with science". (C1, P3, 122-125)

"My ambition was always something in medicine but now actually I believe I can be a scientist". (G2, P1, 84-85)

"I have wanted to be anaesthetist since I was small, but I am inspired by the professor and scientist in the laboratory. The research they are doing is actually new to our country and I am into it too. Well, let's see what will happen later". (G2, P2, 86-88)

It is clear from these statements that SRBCs had given them exposure to how scientists work and the pride and joy which they can have by being in the field. However, there were some of the students who thought differently.

".. after participating, I found science is actually difficult".
(C2, P1, 87)

"I want to join Business after this, as I can market my own invention". (B1, P1, 36)

This student continued by adding:

"I want to be a businessman. I can't be rich by being a scientist. Scientists are those who are being manipulated by businessmen. So why should I be one?" (B1, P1, 42-44)

He was not alone in this belief. There were other students from the other boys school B2 who had the same determination and ambition despite the impact of the SRBCs:

> "I want to be an architect, it [the competitions] doesn't affect my ambition. I like something to do with architecture and designing new things". (B2, P1, 30-31)

> "I don't have any [ambition]; I just want to change the world to be a better world". (B2, P2, 20-21)

To sum up, participating in SRBCs had not really changed these students' ambitions, particularly in terms of science and technology. However, those who were involved directly with science research activities outside their school compounds showed more determination and confidence to continue their studies and to become scientists, but this did not apply to those who had worked on their research in their school laboratories. Nevertheless, on the whole, participating in SRBCs had promoted and motivated all of them to venture more into the field.

Those participants who had had the opportunity to work on their projects with scientists outside the schools appreciated the commitment and significant contribution which scientists make to their nation and to improving the world. There are therefore different perceptions towards scientists depending on the amount of direct involvement with real scientists that students have.

From the interviews and diary entries, it seems that some students were shying away from being scientists because they perceived studying to be a scientist to be more difficult compared with other science fields, including medicine, that scientists are not paid well and that science does not really contribute to the national development.

From the responses quoted above from the interviews and diaries, SRBC participants had in general benefited considerably from their experience.

i. Students in G2 believed that participating in SRBCs promotes the various types of career in science: it motivates them into a continuity of interest in science as a career; it influences their future career plans and has a positive impact on their future being in science research areas.

ii. Boys in both boys schools thought that involvement in SRBCs did not contribute much in promoting and motivating them into a science career. Furthermore, it did not change their existing career intentions.

iii. Students in the co-educational school C2 showed that SRBCs motivated their continuing interest in science careers and had a positive impact on their future career planning. From their comments in the interviews, they were interested in being able to do science research.

iv. Inexperienced participants in school C1 stated that participation in SRBCs had changed their future career plans. Because they believed that doing research in science is actually difficult, it therefore had a negative impact on their career future planning.

> P3: “The competition doesn’t give much impact to my
> future career.
> P2: No, it is just like another activity to us”.
>
> (C1, P2 and P3, 108-109)

The SRBC participants who were in their early high school education had their dream career choices. Their comments in the interviews and their diary entries showed that their participation in the competitions was not really due to their ambition to be scientists, but more to their desire to do something challenging and interesting and to be the most capable students in science and research in their school. So it was really too early for them to decide that their career choices would based on science and research. However, by participating, they gained new experiences in the practicality of science content and had acquired skills beyond those which they had learned in classroom. As a result, their interest in doing more research in science, and their skills and confidence in doing science developed accordingly. With this exposure and interest, hopefully they would not hesitate to continue to be in the science area.

6.3.2 The impact of SRBCs on students' responses to science in general

This section reports the students' experiences of SRBCs in building and sustaining their responses to science. The issue is discussed under two major themes; interest in science and research activities, and interest in science issues.

6.3.2.1 Interest in science and research activities

From the interviews and the students' diaries, three main areas were identified which were associated with science and research activities when they had participated in SRBCs, and these will be discussed next.

i. Science and research attributes

The practicality and the uniqueness of science lie in the logical explanation of nature and everyday phenomena and the capability to innovate new tools and techniques for the benefit of human kind. This is true of a range of disciplines taught formally in any school classrooms as the basic chemistry, biology and physics. However, although it offers a diverse spectrum of subjects, science in schools is simply not enough to explain all the phenomena and satisfy all the curiosity held by students. By being able to participate in SRBCs, students go through a great deal of science and research experimenting procedures and knowledge related to their area of interest. Generally, the participants in this study were excited about the new experience which they gained, especially when it involved nature and research. Evidence of this was gathered from comments made by students in B1, B2 and G2.

> "It (SRBC) adds more excitement to science". (B1, P1, 38)

> "I am into science innovation. I just liked it since I was small ... I am happy if I can create something new. It is a satisfaction for me". (B1, P1. 24-26)

> "Before this, I just study. But after participating in this competition I can really apply what I have learned in class. This was made possible by the information I got during the programme. And that means a lot to me". (B1, P1, 28-30)

> "Science is very broad; I am into it since I was small". (B2, P2, 18)
> "I am into research compared to science. I can get new information every day. To me science and research are overlapping". (B2, P1, 9-10)

The boys seemed to appreciate the experiences more than the girls as it involved considerable freedom for exploring and developing their ideas. The practical aspects of the SRBCs in requiring them to do science research had given them a new experience of science. Science turned out to be interesting when it incorporates research elements. Nevertheless, this was not only enjoyed by the boys, but the girls in G2 also expressed their gratitude for being able to do research in science. They expressed their satisfaction towards it clearly:

> "We just love to do research". (G2, P1, P2, P3, 23)

Applying science in research was something new to the participants; it brought them nearer to the understanding of content which had previously been patchy and compartmentalised by the education system. By integrating the content and the scientific skills, they were able to solve mysteries and innovate something useful for human benefit. Thus, participation had contributed to their satisfaction and confidence in science and specifically in scientists.

ii. Autonomous learning experience

Carrying out science research according to their individual interest and curiosity had brought an autonomous learning experience for them. They were free to create their own research questions, make their own hypotheses and design their own experiments. All of their activities were independent but supervised. Therefore, the sense of ownership and responsibility towards the sound findings of their research depended on their level of curiosity, the time frame available and their willingness to go out to find information and available facilities.

> "It is self satisfaction; I don't mind not winning, as long as I can participate in the new competition". (B2, P2, 11-12)

> "It doesn't really have to be what we invented, but what we learned along the way during researching, and it was really interesting. We were able to understand something". (C1, P3, 129-130)

> "It always felt good to learn this way. I really appreciate the knowledge now. If I have the chance I would just love to do more research in the future". (B2, P2, 27-28)

Besides enjoying their time in doing something independently, they were also granted some privileges in terms their overall science studies and the opportunity to mingle with new people.

> "Between science and research, I am into research more. Inventing a new thing is my passion. It helps me to understand science better. I scored all As in my science subjects".
> (B1, P1, 33-35)

> "Firstly, gain more experience in doing research, new information and in competition have the opportunity to meet and know people".
> (B2, P1, 6-7)

Being able to experience an autonomous way of learning, the participants celebrated this independence and lively way of content acquisition.

In summary, the autonomous way of making science discoveries was enjoyed more by the boys than the girls. For the boys, the main attraction of the competitions was the freedom they gave to them.

iii. Curiosity and satisfaction

Being young and energetic, the participants believed that participating in SRBCs satisfied their curiosity.

> "It satisfies our curiosity and thirst for exploring new things".
> (G2, P1, 130)

> "Research ... I just like to push my curiosity further".
> (C2, P1, 75 & 78)

They were satisfied at being allowed to do what they felt inspired by. This gave them the joy of learning and the excitement of exploring science.

> "For me, when I identify new things, I will easily be attracted to know more about it and explore more especially on the medical stuff". (C2, P1, 82-83)

Their interest in autonomous learning was very much related to their preferred way of learning things.

> "I am a person who is blessed with ideas, sometimes the teacher will easily get irritated with my questions in class. I just love to play with my ideas and imaginations. I will explore and manipulate the idea until I am really satisfied. Probably that is the reason I have been chosen by the teacher. I just love to do something different from others. (B1, P1, 14-17)

> "For me, I become more critical on [issues to do with] nature and the environment. I ask more questions and I try to find out more information on it". (G2, P1, 71-72)

By acknowledging their style of thinking, their participation definitely brought out their real talent in science. However, not every participant was in the same boat. There were some participants who were unable to be independent and curious about what they doing. These participants needed a lot of guidance in order to accomplish their tasks and satisfy their curiosity.

> "After doing some research, we started to get confused as all the facts we all gathered were different from each other. We were so disappointed for the whole week". (G1, P1: 1/27-29, week 2)

> "I am curious but I don't want to do research in depth, just to use the existing science and play with it". (C2, P2, 80-81)

Curiosity is 'the thing' in the SRBCs. All the projects are done on the basis of the participants' curiosity. Participants' curiosity levels are undeniable high and that is the reason why they were selected to represent their schools in the competitions. However, their curiosity needs guidance and help from the experts in order to reach 'satisfaction' and 'beneficial' levels. This is true because satisfaction can only be reached when all the curiosity is answered and benefit can only be gained when the findings are sound and practical.

Participants' interest in science and research activities varied; some of the participants were attracted to the research component more compared with the pure science learning. There are a few interesting points to observe on this issue:

i. The boys in the boys schools commented that science is more exciting and satisfying when it involves a research component. They seemed not only to enjoy science but also to understood it better. This was due to the hands-on / minds-on investigations and active involvement in conducting their own research.

ii. All of the participants agreed that they enjoyed learning something new through research and experiments. They had the autonomy to work out what to do next and could decide on each action taken. The responsibilities which they were given were the motivation for them to want to go on to explore science further.

iii. They also believed that SRBCs satisfied their curiosity on everyday issues. They were given platforms to justify their assumptions and work out their ideas into something which is beneficial to human kind.

Interest in science and research activities developed through participating. With time, hands-on / minds-on activities had satisfied their curiosity on everyday issues.

6.3.2.2 Interest in science issues

From the interviews and the students' diaries, three main areas were identified which were associated with participants' interest in science and research issues when they participated in SRBCs, and these will be discussed next.

i. Looking at issues from different aspects

Science is the knowledge of nature, and it welcomes many different interpretations and discussions. There are always pros and cons in each issue raised in science. Doing research in science in the SRBCs had allowed the students to think about specific issues and react accordingly with the support of evidence and data. This in turn exposed the students to broader aspects of discussions and perceptions on issues that were raised. According to one participant in G2, SRBCs had changed the way she observed and looked at particular issues:

> **“**... plus it widens our perspectives; we were able to look at certain things in a new way especially in bio-technology”. (G2, P2, 131-132)

Her opinion was second by her research mate:

> “My awareness towards environmental issues rose with the project. (G2, P1, 73)

Both of these participants were involved in a bio-technology research project which took place in one of the local universities in Malaysia. They attended extra classes in the university in order to understand the concept involved in their research. Their research was closely monitored by the bio-technology professor in the university. With their positive attitudes and exposure, they won first place in the national, residential schools, and world SRB competitions. They claimed that SRBCs had contributed to their interest in exploring science issues, and had opened up their perspectives on particular issues.

ii. Interest in real science issues

Being involved in a science research project for months was found to contribute to the increase of interest in real science issues among the participants. They had deepened their interest particularly on the subject area under research.

> “I was not interested in science before this. After joining this competition, I think science is quite interesting”. (C1, P2, 126-127)

> “For me, I appreciate the environment more after the competitions”. (B2, P2, 17)

Their interest developed not only in environmental issues but also in their science subjects:

> “It increased my interest in my biology and physics subjects. I am doing more into physics, so I understand more things which are related to it compared to the rest”. (B2, P1, 26-27)

> “... have deepened my interest in biology and chemistry”.
> (C2, P1, 63)

To be able to incorporate the three main components of these subjects together is something to be celebrated. The scientific skills are the only similarity involved in these three subjects. By being involved with a real science project, participants cannot separately address the problems and the solutions strictly on the basis of one particular subject. All three of them must be involved at the same time. Therefore, SRBCs are a platform which enables the participants to associate the three components and to have an holistic understanding of science issues. By reaching this stage, the students eventually deepen their interest in current science issues and value the knowledge more.

iii. Reacting to science issues

Involving themselves in serious science research activities for months had obviously deepened the students’ understanding of science, particularly in the area they researched. With the development of their understanding and interest, it is entirely possible that they will have raised passion towards the area. This was confirmed by participants from B1, B2 and G2:

> “It adds more excitement to science. It is so beautiful and meaningful. It is so adventurous for me. And it is very important for our life. It gives answers to the things I do in my life”. (B1, P1, 38-40)

> “Obviously it helped me. When I observed things, especially factories, it strikes me to do something on trapping and filtering the

smoke and so on in the house. After inventing a new device, I am satisfied with the project. I did lots of research on how to filter dust and unwanted particles". (B2, P1, 20-23)

"For me, my interest is in machines, so when I see a machine there is always in my mind how to make it work better and maximize the function". (G2, P3, 75-76)

"My awareness towards the environmental issues rose with the project. After this, we will keep on trying to improve for the sake of the environment". (G2, P2, 73-74)

The striking similarities between the participants' responses on this issue show that all of them had similar experiences in SRBCs. They had been involved in their science research activities for more than a year. Being involved intensely with the same projects for more than a year had definitely given them a passion for the subject. That is the reason why they were able to react to science issues.

It can be concluded that participating in SRBCs is helpful in cultivating interest in science issues. Being young in their science streams, the participants had shared some of the attributes that they had developed along the way:

i. Through participating, they perceived that SRBCs had increased their interest in science especially when they were given the opportunity to work outside the school system. The exposure had given them valuable experience in knowledge development and in strengthening their scientific skills.

ii. The boys in the all-boys schools perceived it as meaningful. They admitted that SRBCs has encouraged them to react to science in daily life issues. They had become proactive and had innovated new solutions for observable phenomena. However, only girls from G2 shared the same point raised by the boys.

Their interest in science issues had developed according to the level of exposure to science and their confidence in doing and learning science. The boys were more affected by these attributes. They understood science better and had high curiosity and imagination in terms of solving the identified issues. However girls' interest towards current science issues developed with the extent of their exposure to working outside their school compounds.

6.4 Summary of the findings in the impact of SRBCs on school science and science in general

From the information gathered, common and significant factors which emerged from the study were highlighted. The summary provides a deeper understanding of the subject and the factors contributing to the students' overall responses towards school science and science in general after participating in SRBCs.

i. School G1

Received support from school administration. Started late due to unsettled issues with the research topics. Had lots of problems with the research. Received motivation and guidance from peers, teachers and external mentor. Experienced problems with time management and research facilities in schools. SRBCs satisfied their curiosity on science issues.

ii. School G2

Received full support from school's administration. Started early. Upon participation, have very positive attitudes towards school science. Received guidance, motivation and help from peers, teachers and external mentors. Motivated to continue pursuing science and research activities. Appreciate hands-on activities which involved science and research activities. Participation had an impact on their career choices. Helped them to think and appreciates science issues.

iii. School B1

Received less support from the school's administrator. Started very late due to late notification. Upon participation, had increased self-efficacy towards science subjects. Much appreciated the hands-on activities. Faced problems with time management and focusing on the project. Did not have any impact on career choice, but enjoyed the activities which challenged curiosity and creativity. Thus participation helped to react in daily life.

iv. School B2

Received full support from the school's administration. Started late due to time constraints. Participation developed interest in learning school science thus increased self-efficacy on the subject. Much appreciated the hands-on activities which involved science and research. Did not have any impact on career choice but enjoyed the activities which challenged curiosity and creativity. Increased interest in science issues and encouraged to react in daily life.

v. School C1

Received full support from the administration, however had lack of experience in collaboration with external agencies. Much appreciated the hands-on activities which involved science and research. Had mixed feelings about joining science careers as it seems to be difficult. Yet, increased interest in science issues.

vi. School C2

Received support from school administration. It was a continuing project from the previous year. Had problems with internal and external mentors. Lead to delays and frustrations. Appreciated support from peers and parents. External help expanded knowledge and motivated them into science career. Had problems with focusing on the project and with time management. Enjoyed research but did not satisfy their curiosity much. Much appreciated the hands-on activities. Increased interest in science issues

The students' positive responses towards school science and science in general after participating in SRBCs was much influenced by the school culture and support and by the quality of external help. This is very much aligned to the components that make up attitudes shown in Figure 1 (environment, teachers, activities, peers and gender). Schools which had science as their niche areas seemed to be more supportive in science activities and had assigned committed teachers to be the project mentors and initiated smart collaboration with external agencies. They encouraged early preparation and permitted students to do research during school hours. In the short term, the students appreciated the benefits and enjoyed the school science learning very much, while, in the longer term, their interest and confidence in science and research grew accordingly.

From the students' comments, participating in active research competitions was found to be beneficial in instilling new values of science and technology, adding new experiences of learning school science, creating a better image of people working in science areas, and developing a sensible interest in pursuing careers in science and technology. These benefits support the frame-work shown in Figure 2 on the impact of attitudes to science.

Having the chance to work with an external mentor on their research project increases the students' appreciation towards the reality of science and technology and increases their attitudes towards science. This finding is in agreement with Oppenheim (1992) (as stated in Ramsden, 1998) which indicates the positive values of science and technology inferred amongst the students suggests increasingly deeper levels of 'attitude' and concern the most stable and enduring aspects which govern affective responses. The students' value honesty, accuracy, consistency and persistency of science and technology especially its capability in addressing and solving current issues thus, confirming the relationship of the positive value of science and technology and the positive attitude towards science as in Figure 2.

Chapter 7: Teachers' Perceptions of SRBCs and of Students' Responses to Science

Overview

This chapter explores teachers' perspectives on their participation in SRBCs and their perceptions of the participants' responses to science during and after participating in the competitions. Five teachers participated in this study. As the people in charge of the development of the projects and of students' participation, they are the people most involved in this issue and therefore the most appropriate to share their views on the students' responses to learning about science and to science in general. Furthermore, being mentors to the students, they have experienced the real challenges and enjoyed both the glory and misery of competing together with the students. It will be therefore interesting to understand the stories behind the scenes which can be told by these five teachers. Their input will therefore be used as supporting material for the claims made by the students which have been discussed in previous chapters and as an evaluation of the programme and of students' responses to science development.

Interviews were conducted with five of the six teachers in charge of competitive projects in the six sample schools. They were chosen on the basis of their recent involvement in a Science Innovation and Engineering competition held in May 2010. The missing respondent was a teacher who taught in G1. This was because she declined to be interviewed because of her tight teaching schedule and her other commitments.

Table 18: Distribution of teachers according to gender and types of schools

Type of School	Female	Male
Boys School	-	2
Girls School	2	-
Co-educational	2	-
Total	4	2

Each semi-structured interview session took about 30-45 minutes and was conducted in their individual school premises according to their availability. The interviews covered six principal questions and were carried out in the Malay language, although the respondents were free to reply in English, in Malay or in a mixture of both languages. The interviews were recorded with the teachers' permission, translated, and produced as transcripts in English. A copy of the interview schedule is given as Appendix F.

As internal mentors to the participants, the teachers were asked about their perceptions while mentoring students in SRBCs, about the most challenging tasks encountered during the mentoring, about the impact of the competitions on their students' reactions to knowledge of science and understanding of science in general, and about their views on offering more opportunities to more students in future competitions. The findings were categorised into four themes; commitment towards the SRBCs, challenges encountered, teachers' perceptions of participants' responses to science, and the future of SRBCs in Malaysia.

7.1 Commitment towards SRBCs

Over the years, Malaysia's Ministry of Education (MOE) has put much effort into science activities to instil students' interest and encourage their involvement in science learning and their desire to pursue science at tertiary level. Teachers are key players who hold the most important role in integrating and implementing non-academic programmes and realizing the national inspirations. The responsibilities for SRBCs are additional to their academic duties. An SRBC is one way to increase students' interest in pursuing science at tertiary level and as a career pathway. It is also a part of a national programme which underpins the realization of Malaysia's mission to become a fully developed country by 2020.

Teachers in the residential school system have more obligations, especially in occupying their students' needs and time with activities, in comparison with their colleagues in the normal school system. They have to ensure continuous excellence in achievements in both academic and extracurricular activities. They are not only responsible for occupying students with activities tailored for residential school students but also for acting as their guardians and life-coaches. To participate in a prestigious competition and to uphold the dignity of the school's name very clearly asks a big sacrifice of time and extra commitment from the teachers. They have to prepare young minds in how to conduct research, to acquire scientific skills, to communicate their findings and to overcome the obstacles which they will inevitably encounter during the exploration. They also need to identify external experts, laboratories and funding to indulge the curious minds of high-spirited young people. In addition to all this, they also have to handle the hiccups which are bound to happen until the participants have successfully completed their science research competition projects. There are no extra incentives or fees for them: their determination and inspiration is simply the consequence of them accepting their responsibilities of cultivating more future elite scientists for Malaysia.

7.1.1 Teacher Participation

Records show that residential schools in Malaysia have been officially competing in SRBCs since 2000. There are about twenty science activities offered by the Ministry each year. Some are designed to match the capabilities of lower secondary students and some are specially designed to challenge upper secondary school students' capabilities and interest in science. There are five major science research based competition activities in the upper secondary school: the Science Innovation and Engineering Fair, F1*inschools*, Rocket Launching, Robotics, and Solar Race. These competitions are organised in order to select the best Malaysian representatives to take part in international competitions. As a result of having a pool of bright Malaysian students in the residential schools, it is a responsibility for each school to participate in the SRBCs. Every school has its secret intention to be the winner in order to represent Malaysia in the international arena. In the long run, participating had turned out to be a very competitive and prestigious annual event among the residential schools.

The interviews revealed that all of the participating teachers were appointed by the school administrator. With determination to win in mind, the teachers had been carefully selected from among science teachers who are dedicated, committed and expert in different kinds of science and engineering fields; some of them specialised in Physics, others in Chemistry and Biology. They were selected to be in the programme on the basis of their background and talent. Most of the teachers interviewed were responsible for the programme continuously from one year to another.

> "I was appointed by the administrator and have been participating in the competitions for six years [2004]". (B2, 2)

> "It has been eight years, from 2002-2010". (G2, 1)

> "I have been participating since 2003, and we won first place that year ... till now". (C1, 11)

> "We started in 2000 till now [2010]. I have been involved in many science competitions, but this is the second time I have been really involved in innovation projects". (C2, 4-5)

Through years of mentoring and managing various kinds of science programmes, these experts eventually deepened their passion for carrying out research with their students:

> "... it is because of the responsibilities prearranged by the administration. We have to guide and take them to competition level. But most of all.... the most motivating factor is my own interest and drive on the project itself". (C1, 5-7)

However, there are some who have just had enough of it:

> "Actually this is a yearly competition for the residential schools, and automatically, as the head of science, I need to be in charge of the programme. So, I am not really interested in it, it is more the competition basis that makes us participate in it". (C2, 7-10)

This teacher was not alone in reporting having no interest in being involved in the programme; it was just another job requirement given to her which needed to be obeyed. Nevertheless, she agreed on the importance of the programme and on the immediate and long-term benefit to the students, however there were a number of reasons which had contributed to her loss of interest:

> "Innovation is such a good activity, but the long hours of preparation are a burden". (C2, 88-89)

She then added,

> "If only research can be included into the co-curriculum, the students will have a proper programme on how to carry out scientific research and so on. We can teach the students about report writing, abstracting and science process skills from when they were young. So there is more innovation each year and all the teacher's hard work pays off". (C2, 90-93)

This is a set of comments from the same teacher who actually felt like giving up on the workload with which she had been burdened. Not only did she have responsibility as the head of the science department, she was also the only Biology teacher for six upper secondary classes and six lower secondary science examination classes. The academic workload and the administrative responsibilities which she held definitely produced a tremendous downside for her. However, with her determination, her group had managed to win silver in their recent competition. When the researcher asked about her next year's project, she deliberately replied diplomatically:

> “Mmmmm, I would like to give the honour of the experience to other teachers.” (C2, 18)

Her comments are practical and she certainly spoke with deep feeling. A similar comment was made by a teacher in B1 regarding his involvement with SRBCs:

> “I don’t have any interest in innovation and science competitions. In fact, each year I have asked for a change from the administrator but they have always rejected my request”. (B1, 18)

He then elaborated his opinion:

> “This might be due to no teachers wanting to become involved in this activity. More teachers just focus on the academic side, furthermore they are aware that supervising students who are involved in innovation projects demands a lot of their time during their leisure hours. So, the administrator just picks out and forces a specific teacher to help out”.
>
> (B1, 20-23)

These teachers in B1 and C2 were reluctant to be in charge of students’ projects. They engaged themselves in supervising the projects and the team simply as a job obligation. Their disinterest showed and indirectly affected the progress of their protégés. Participants in both schools (*see* Chapter 6.3) reported that they faced many problems with their teachers. However, on the other hand, the mentors in schools G2, B2 and C1 had an opposite view; they were excited and looked forward to assisting their students’ projects and competing. One of these teachers said:

> “The students have the talent for research but they can’t develop that talent by themselves, they need some guidance from the teachers to develop it. And it is also self interest”.

(G2, 4-7)

This teacher's positive attitude to the responsibilities was also recognised by her students; it provided them with motivation and encouragement. They became more positive and persistent in their research and looked forward to exploring their topics far more than the participants in B1 and C2.

No matter what the reasons and factors were which influenced their participation, the teacher's role as mentor, manager and programme coordinator is unquestioned. They tried their very best to fulfil the job obligation and they have demonstrated their commitment over the years without complaining. They never fail to keep on recruiting students to construct innovations and produce inventions which have been proudly entered into competitions year after year.

> "In this school, the administrator has been assigning teachers for each competition earlier every year, so the teachers are aware of their responsibilities". (C2, 14-15)

> "We look at the students' interest in new topics; they are so excited about it. For me, we have learned about doing research during our university years, especially when writing a thesis. So it is a waste if we don't continue it. So, I just love to assist students, especially when they have new ideas". (G2, 10-13)

The teacher's level of commitment to the project does play a big role in the success of the programme. With the trust placed on them, the teachers get on with their task willingly even though they are fully aware of the sacrifices and devotion needed to ensure the success of projects for which they are responsible. On the managerial side, participation in prestigious competitions will definitely have a high positive impact on a school's overall reputation and recognition. Furthermore, it will also make a significant contribution to the national education system. Therefore, the right teacher is needed to take on the responsibilities. A teacher's interest, willingness to get involved and level of commitment should be taken seriously by the school administrator before putting them in charge of talented students. This is essential in order to ensure proper guidance and direction for the maximum benefit.

7.2 Teachers' aims

Mentoring the projects was regarded as a platform for the teachers to enable their students to develop their talents and skills, especially in carrying out scientific research. The teachers also mentioned the opportunity to guide the students to have positive attitudes and to maximise their capabilities during the preparation periods. They believed that a talent for science and research is something to be nurtured and guided in order to develop it properly.

> "This is a platform for guiding the students to do scientific research. The students haven't been really exposed to it and given ample time before, and this opportunity will enable us to guide and help them through". (C2, 11-13)

This is a remarkable comment made by the mentor in C2 after her complaints discussed above about having too great a burden and participating only because of her job obligation. It shows her positive belief in the programme and the benefits which it brings to her students.

In the interviews, none of mentors mentioned anything about the need to win the competitions or about the hope of representing Malaysia in an international arena. Neither did any of them mention anything about cultivating young elite scientists for Malaysia 2020. Teachers' intentions and the challenges were very clear. Their main concern was to ensure participation from their school and to guide the students' interest in doing scientific research. The teachers acknowledged their students' talent and believed that it can be nourished and developed appropriately. Their intention was to nourish, engage and develop their students' talent in science for their students' benefit, and in this particular case, that intention ran parallel with winning the competitions. Recognition of their work is granted when their students' win any of the competitions. This is not only a boost for their self-satisfaction, but also leads to self-recognition for their effort and abilities.

7.3 Challenges encountered by teachers

Science research competitions are an *ad hoc* activity conducted in schools. There is no specific programme, club or time-table allocated for this type of competition. As with other competitions, all the preparation has to be carried out as soon as they receive a letter of appointment from the school administrator. The 'ever-ready' attitude which is built into the teachers' training is the ultimate strength that makes the programme a success. It is an additional responsibility for the teachers just as it is for the students in order to achieve individual recognition and the school's satisfaction.

The following sections present the responses collected from the interviews when the teachers were asked, 'what is the most challenging task for you and your students in pursuing the competitions?' The responses are grouped according to the similar themes found: work load, time frame, writing, students' compatibility, administration, and funding.

Work load

> "I don't have any interest in innovation and science competitions. In fact, each year I have asked for a change from the administrator but they have always rejected my request. This might be because not many teachers want to be involved in this activity. More teachers just focus on the academic area; furthermore they are aware that supervising students who are involved in an innovation project means giving up a lot of time in their leisure hours. So, the administrators just pick out and force a specific teacher to fill the gaps". (B1, 18-23)

Preparing an innovation team is a big task for everyone because it involves in-depth research, experimenting and communicating the idea as accurately as possible. The task becomes even tougher when it involves a group of young students who have no previous background of research experience, and who are living in one of the residential schools, which means that they rely 100% on the input and effort from their teachers. Therefore, the teacher's role is not only mentoring the project but also supervising the students' development throughout the programme and managing the project for them in a range of science competitions all year round. This obviously demands patience and consistency from the teachers. This was underlined by the responses given by teachers when the researcher asked about the most challenging task in the competitions:

> "... to be consistent in my projects, because of the other duties and responsibilities in school." (C1, 15)

> "Teachers are restricted by time constraints. They are bound up with various kinds of science competition which were assigned to them early in each year. Each teacher has to be responsible for two or more competitions in a year. Lots of boys have come up with good new innovation ideas, but unfortunately we cannot support them all". (C2, 65-67)

Students' academic achievement is the core business in the lives of both teachers and students. It is more significant when they are in the residential school system. There is a responsibility not only to ensure that everyone will pass with flying colours but also that excellence is achieved in every activity in which they participate. The motivation to achieve is paramount in the teachers and that makes them ready to compete and to be completely dedicated to their students.

> “I have to limit myself to two (individual and group) participations a year. We have to reject lots of other competitions as we have lots of other activities in the school”. (B1, 33-34)

> “The students and mentors have limited time. The students need to give up some of their free time to do the project and so does the mentor. There are lots of students who are interested in doing the project, but we can’t support all of them”. (C2, 24-27)

The teacher who made the previous comment then added:

> “Researching on the internet requires a lot of a student’s time. The only available period is after preparation class from 5 till 6pm. These limitations do limit the progress of research. They are bound by a rigid time-table, and if they happen to miss one of the programmes, they will definitely miss another. It is a time constraint”. (C2, 28-32)

Helping intelligent students with their projects along with their academic workload certainly is an extra burden for the teachers in charge. Determination, tenacity and persistence are the main qualities that help them to get through the difficult time. They have to overcome their own stress first to ensure that their students’ project development is going according to schedule.

i. Time constraints

> “Actually, the most troublesome thing for me is TIME, as we in residential schools are always in a hurry and by being involved in this kind of competition, a lot of sacrifices from the teachers and students are needed”. (C2, 21-23)

As mentioned earlier, the time allocation for each competition depends on the official letter sent by the Ministry and on the school’s priorities. For this particular competition, the letter will normally be sent by October for an event in May in the following year. However, during the month of October, teachers and students are fully occupied with their end-of-year examinations and these are followed by a long school break in November and December each year. Although the competition is held annually, some of the teachers and students will only start preparing for it at the end of January or even in early February. This leaves them only approximately two or three months before the event. This was confirmed by the responses from senior teachers when they were asked about their time allocation issues,

> "Normally two months beforehand, and the problem is that I never have the chance to develop the project and expand it properly. As you mentioned to me earlier, that is my mistake. I never concentrate on a project seriously early enough." (C1, 24-26)

> "Time is the most challenging; normally two to three months before the competition, the teacher needs to be with the students in school every afternoon. And for two to three weeks before the competitions, I have to give up my classes too. As you know, Physics has lots of topics to cover". (B1, 25-29)

> "Timing is crucial for us; the students are so tied up with their school activities. So, they normally fail to keep up with the due date. They will work everything out in a month". (B2, 5-7)

All the respondents agreed on the issue of time constraint. Because competitions are an *ad hoc* activity, the teachers reluctantly leave their core responsibility but have no courage to disobey the instruction given. As a result, this creates a shallow and not fully developed project.

> "Time management: as students, they have a lot of other commitments; they need to study for the coming exam and they also

> need to find time for their research. That is the most troublesome thing for them". (G2, 16-18)

With limited time, everything needs to be planned and kept in motion according to the schedule. A little hiccup here and there will eventually add more pressure and hurdles to the completion of the project. From the teachers' experience, a successful innovation project normally takes about a year of preparation. Those schools which have more experience and determination will start working on a project a year earlier. This will result in a mature, well-constructed project compared with the others. Schools which make this effort have continuously secured a place on the stage every year.

ii. Writing

Another area which was particularly problematic for the teachers was report writing. Some of them had difficulties due to lack of experience, but for most of them, the problems were more on monitoring the students' reports for submission. For each SRBC project, the student must prepare a log book, a full written report and posters for exhibition at the competition. If teachers are experienced in report or scientific writing, this will be an additional bonus for them because they could help the students effectively on how to construct a well-presented project paper. Editing and rewriting can be mind-numbing for someone with a deficiency of experience.

> "Writing, because I, myself, don't have good experience in writing up a project properly, so I am unable to guide them well, so there is lots of important stuff omitted when we are preparing the project paper". (C1, 28-31)

> "I used to remind them to write up every week, but they normally don't do it. The project book is the biggest problem for the boys". (B1, 46-47)

As young scientists, the student participants are required to keep a log book of their experiments and the exploratory activities which they have conducted.

This provides continuous evidence for the judging and for the evaluation of the project. In addition to that, they also have to produce a report on their activities and posters to communicate their findings to the audience. For some, this might be the first time that they have been exposed to the challenge of writing such a large amount. So it is definitely a problem for them, especially when the students have to do it in such tight schedule.

> "The most challenging task is to produce a log book and to develop a patent for a product invented". (B1, 44)

> "Report writing is another problem as the student hasn't been exposing to write scientific report yet. Especially on the scientific writing, it is a problem for not only the students but for the teachers too. In conclusion, we are at the beginning stage". (C2, 38-40)

Having been a mentor for more than eight years, the teacher in G2 pointed out the main problems which have caused her colleagues frustration and despair. One of them was that they lacked science writing technique. A regular winner of SRBCs, she explained:

> "There is no secret actually, but if we compare with other schools probably it is the writing technique and all the scientific processes. Especially when doing an experiment, they didn't repeat the experiments. When they do an engineering project, most of the schools didn't support their innovations with experiment data. What they did was just present the product without any scientific evidence of how they have come up with the new invention. Basically, they lacked data. However, their ideas are terrific and some of them have never occurred to us before". (G2, 24-30)

She then added:

> “Most of the projects that are selected to go to the international competitions are chosen because of the data and depth of research findings; these are the complete ones. All the students that participate in the competitions have lots of beautiful and interesting ideas. However, the students involved in the winning project are normally able to answer all the questions posed by the judge and to explain them in detail with complete confidence. The way they present and argue is logical and scientific”. (G2, 33-38)

In short, a teacher’s credibility and pre-knowledge of research techniques is essential for a project. A teacher’s training in mentoring students’ projects is found to be crucial for the sustainability of the programme in the future. In SRBCs, dedication and adequate knowledge play a major part in the success of their attempts. Ironically, it emerged from the interviews that there were teachers who had been participating for more than four years but still considered themselves beginners.

iii. The students

> “At times the students do lose their way in their research and don’t know where to go with the research and findings. This is actually higher level research for secondary school pupils. From 2002 to 2010, I can say that the students’ projects are on a par with university-level research. So, the students really need guidance and perseverance while doing the research. It is actually a big task for them”. (G2, 47-51)

The creation of a sound project does not depend just on the teachers or on the students, but on both. Their combination and chemistry over working together will always be an extra strength to the success of a project. Pro-active students and dedicated teachers will explore more and have a smoother journey to victory. That is the main reason why the teachers choose to work with the best candidates who have a clear intention and determination. The students who are chosen will be trained intensively and monitored for two to six months.

> "… most of the students are compatible with our style". (C1, 18)

However, some problems are encountered along the way, such as communication skills, language proficiency, limited ideas and access to better equipment and expert knowledge. For example, the boys schools had a serious problem over communication skills.

> "Lots of students show interest in innovation. Each term, I will receive lots of new proposals on my desk. And I will choose the best and I will groom them. I also seek help from others from the university and other expertise to choose the best project. I have to limit the number of competitions to two (individual and group) a year. We have to turn down many competitions as we have lots of other activities in the school. This year, I am lucky to be coupled with a teacher who went to Perlis last month. He has high interest in innovation and new ideas. So, this might activate innovation activities in the school. He has plans for lots of new programmes to develop an interest in innovation amongst the students". (B1, 30-38)

> "The second problems is the language, the boys refuse to talk and are not good at communication skills". (B2, 8-9)

The ability to communicate the findings is essential in competitions. It has to be convincing and well supported with measurable values. These skills can be practised and taught, but the success rate depends entirely on the participants' efforts. Delivering science facts with confidence is an asset for each project. The more convincing the facts, the more meaningful the project will be. All the hard work and sacrifices made will pay off when a project is well presented and makes logical sense to the audience.

As has been explained, a project originates from a student's idea. Some students embark on research which intentionally focuses on the 'proving' style of research, others go for something adventurous and with a practical application. Both types of research have their advantages and disadvantages. For the first type of research, the students will devote most of their research to finding out how things/substances work, what are the active components involved, and why they are being used. This type of research is fundamental research. Normally, this kind of research was practised when the students did not have much experience in research and had limited time to explore the potential use of it. According to the teachers' experience, attempts of this type will have slim chances of winning in the competitions. The second type of participation was likely to be undertaken by the more adventurous students and determined teachers. They were found to be constantly willing to give up their time and put every effort into exploring deeper into the subject. This is focused more on the application of knowledge. Winning teams tend to use this kind of project – projects which include the fundamental study of substances and which are able to add commercial values to contribute for the betterment of human beings.

> "To them it is more about finding new things about the activities that had been practised by their mom and grandma back home. Most of them will come up with new ideas, which they don't know how to prove scientifically". (G2, 69)

This type of research involves a high degree of investigation and exploration. The teachers and students need to know the root cause of everything and come up with an applicable knowledge/gadget/system or even new processing methods. To conduct such research, they need to collaborate with universities in order to have access to recent journals and to obtain permission to use the university's laboratories and equipment. Research of this kind allows the students to access the information needed and to gain first-hand information on their research areas. It is definitely the more enriching type. Normally it takes at least six to twelve months of intensive continuous effort to accomplish it.

> "They also find difficulties when carrying out their research, as the school doesn't have all the equipment needed, so sometimes we have to travel backwards and forwards to the universities. The universities are quite far away, so that is also a challenge for us". (G2, 19-21)

The most challenging thing for the teachers was to develop their students' ideas into something which is marketable and scientifically proven. Dealing with students' research and managing the problems which emerge had not been a problem as it has been a part of the teachers' routine, especially when the teacher has six to ten years of experience in the area. In conclusion, teachers have been giving up their time and building up their own interest and commitment in their determination to achieve success for their students' research projects.

iv. Administration

School administration is led by the Principal and three senior assistants who are responsible for student affairs, co-curriculum and academic development. Work for science research based competitions will be supervised by the co-curriculum senior assistant with the help of the head of science, and they will approve the budgeting and the students' research activity. In a residential school, supervision of students takes place 24/7 so preparation activities involve all the senior assistants. The more support and understanding there is from the administrator, the more feasible and manageable the programme will be. This is especially important when dealing with funds, grant applications, research permission, working outside school and obtaining permission for teachers and students to leave their classes and schools to carry out field work.

> "Cooperation from the administration side is quite good". (C1, 19)

Most of the respondents were satisfied with the cooperation and moral support they had received from the administration. However, there were a few issues which were brought to attention. First, the difficulty in persuading the school administration to set up a mutual relationship (a Memorandum of Understanding, or MOU) with nearby universities. By having an MOU, the students can have the privilege of using the university library, of consulting experts, and of having access to scientific instruments and advice on their current studies. This can lighten the teachers' responsibilities.

> "The other problem is we don't have any good connections or MOUs with the local universities. Right now, we really hope to have a formal relationship with the nearby universities so we can venture out further". (C2, 33-)

This teacher then elaborated on this issue:

> "We really need more teachers and external mentors to guide the students. We as mentors really need to know how to outsource the right external mentors, or the product will just be the something ordinary". (C2, 119-121)

Second, the limited number of teachers assigned by the administrators to monitor science research activities creates a limitation to the projects every year. With their existing academic workload, teachers can afford to monitor only two projects at one time, so more teachers are needed to cater for growth of interest among students.

> "Unfortunately, we don't have enough teachers to guide them through. The students have ideas but they don't know how to develop them into an innovation. Most of the time they will seek and depend on their mentor's guidance. As there are not enough teachers, so we have to limit the entries to two to three projects per year". (C2, 60-63)

With good support from the administration, students' progress in their research will flourish and this can ease the burden on teachers. Their involvement in setting up MOUs with nearby universities is definitely an advantage for all the students and teachers involved.

> "There are common research trends amongst the participating schools. Some of the schools are very lucky and benefit from MOUs with universities. Innovation projects need lots of patience, perseverance, time and effort". (C2, 113-115)

The teamwork between the administration personnel, teachers in charge and students can be translated through the work which is produced. The winning schools were obviously satisfied with their administrative roles. They had no complaints about their teammates or their mentors. Mutual understanding between the three parties and the moral support which is provided definitely ease the burdens faced by the teachers and the participants.

v. Funding

Money is an important commodity for any innovation. Many experiments and investigations involve exploration and testing and without sufficient financial support, the space and effort for exploration will be limited.

> "Funding the project is another problem. Good funding makes us move further, so in my case it slows down the research momentum as there are fewer funds". (C1, 19-20)

Some of the teams were well funded by their schools, but even so the amount allocated is limited according to the sources. To venture into a bigger scale project, the teams need to have larger budgets. The schools need to acquire sponsorship and help from other institutions or individuals. However, this is not a problem in residential schools, as these schools have their own funds to support the development of the projects appropriately each year.

> “We don’t have any problem with money. We can always ask for money from the school”. (B1, 39-40)

> “Money; so far, the projects have been supported by the school administration. As it is not a big project yet, we have just used the curriculum funding”. (C2, 36-37)

From these comments, it appears that schools B1 and C2 played a positive role in supporting the success of their students’ projects. However, for ambitious and adventurous teachers, to have access to more funding is satisfying. With more funds, they have more freedom to explore and experiment without the need to wait for the administrator’s consent and written approval.

> “From the budgeting side, it is difficult. When we do our research, we really need cash in hand. We can’t afford to plan ahead for some of the upcoming needs”. (G2, 93-95)

Cluster schools that have science or research and development as their niche area have had the advantage of a RM 15k grant each year from the Ministry for the past two years (2009-2010). This is to develop their research and development programmes. These fortunate schools (including G2) have the freedom to use the allocated money for nurturing their student’s interest in their niche area. But those which are not selected for this additional funding have to find their own sources to support the research and the team’s expenses.

7.4 Teachers’ perceptions of participants’ responses to science

This section is divided into three parts. The first part (7.4.1) explores the teachers’ views on their students’ participation in science research based competitions (SRBC) in relation to their knowledge of science and scientific processes. The second part (7.4.2) considers their views in relation to the students’ affective responses. The third part (7.4.3) examines other responses made by the teachers about students' participation. All of the views reported here were gathered from the interviews.

7.4.1 Teachers' views of students' knowledge of science and scientific processes

Knowledge of science and scientific processes can be observed, and generally some information about knowledge and skills can be inferred from sources such as students' behaviour, language and day-to-day interactions. Being both internal mentors for the projects and science teachers in the classroom, teachers are in a good position to note any indications of the development of the students' knowledge of science. Furthermore, years of experience in mentoring students enables teachers to generalise on the responses to science which grow right in front of their eyes:

> "For the Form 4 science process skills, I can't see much as I am not teaching them but for student X (in Form 5), I can see that his science process skills are better compared with the other students at his level". (C1, 45-47)

The teacher who made this comment then added:

> "I think it is shown in everything; the participants developed a skill where everything they did can be related to something else, the impact of doing it, and they can see the cause and consequences which result from everything they do during the experimenting process". (C1, 42-44)

The changes most perceived by the teachers were improved science process skills. With intensive experiments being done for two to three months, the students acquired these skills easily. They can be seen to become more confident and more adept when they are performing their school laboratory work. Another significant difference between participants and non-participants is that participants are able to discuss their ideas, especially in science. They speak up confidently and bravely and use logical arguments with their teachers and peers on something which they may be certain or uncertain about. This does not always happen in Malaysia's classrooms, as students are generally more obedient and rarely confront their teachers on something which seems to them to be ambiguous.

> "These selected students are intelligent students and good at presenting their idea to others. Their capability with the teachers is notable. They are not scared to talk about and discuss their science ideas". (C2, 95-97)

> "The students were able to give good sense of reasoning/justification when challenged". (C1, 48)

The participating students turned out to appreciate subjects more when they were taught with lots of applications of knowledge. This was regarded as one of the qualities found among participants because they become actively involved with something that is engaging and applicable. Even though it involves a great deal of preparation on the teachers' side, it is much more satisfying. This was greatly appreciated by many teachers as it reflects the development of higher order thinking skills among their students.

> "... most students become more interested in the subject/topic which they are dealing with. They show interest in class especially on the application side. They will know what to do for their future undertakings. They will benefit more if they work with outside mentors". (B2, 15-17)

Experience of carrying out experiments outside the school was found to be very enriching. It helped them to associate more easily the things they have learned in the classroom into something applicable to everyday situations. In other words, they learned the application of scientific knowledge through being involved directly in their projects.

> "The application of knowledge they learn in classroom is well understood and makes sense to them when they are exposed to the real research environment in the university". (B2, 23-25)

However, this benefit is limited only to the subject which they are researching. It became an after-effect of the intensive exposure to a subject, which explains why participants who were involved with external mentors had higher confidence in science, but particularly in the subjects researched. On the other hand, those who participate by relying only on text books and materials gathered from the internet did not have much confidence when talking about their subjects to their friends and teachers.

> "It is only for a certain subject. For example biology and chemistry, they can apply their knowledge to it. In class they didn't show much difference from other students at their level, but the only thing which differed was their level of interest. Their skills and knowledge on the subject matters are about the same". (G2, 68-72)

7.4.2 Teachers' views of students' affective responses

As mentioned by the mentor in G2 (who had been mentoring participants in SRBCs for eight years) the participants did not really improve in the subject contents in school as much as they (the participants) claimed. Nevertheless, in her experience, they had a high interest in science and anything which is associated with it.

> "Almost all the students who are involved in this kind of project do show their interest in science. For example, this new group, they really enjoy each time they have the opportunity to learn more than the school syllabus. They look forward to learning more about their research and they actually make an attempt

> to follow the university's classes on biochemical subjects just to ensure they are capable of understanding the mechanisms involved in their research". (G2, 54-59)

So their interest made them more curious about learning science subjects in general; therefore it is likely to make any subject which they are taught more appealing and meaningful. The positive attitudes towards school science learning gained in the SRBCs are mainly a consequence of the increase of interest towards science subjects. Teachers link positive attitudes to improvements in learning. Interest is seen to develop in accordance with the exposure and confidence gained in doing science research, competing with same-interest peers and communicating with adults who have the same interest in science research.

> "Immediately after bringing them to the National competitions, the students have automatically boosted their confidence level. They knew that by participating in this prestigious innovation competition they are already in a different league compared with their other friends at school. They are highly motivated. Everyone knows about them and their project". (C2, 74-78)

> "It is a motivation for them, and they are so excited to see and use all the equipment related to their studies in the university laboratory. It really boosts their motivation in science and research". (G2, 60-62)

The ability to generate interest and motivation towards science learning is considered promising in science education. This is because it can stimulate the urge to do even more than the norm. Hopefully, it will benefit the participants through participation and other students via observation.

> "Most of the students involved in this competition continue to be in a science discipline. They are more comfortable with

> science and subjects related to their previous project. This experience does have an impact on them in guiding them towards the science field for their careers. The science appears to be interesting and easy to them". (B2, 34-38)

This observation made by the mentor in B2 shows that the students' confidence in science is developed by their involvement in the research. They build their interest towards something which they perceive to be meaningful and beneficial for them. The principal advantage is that they can define their choice of interest and it becomes their career choice too. This is definitely one of the inspiring and promising benefits of SRBCs.

Not much information was gathered during the interviews on teachers' perceptions of students' affective responses. They believed that their students' science awareness progressed as a consequence of their involvement in science research. Gradually, their students became more alert and critical towards current science issues. They began to ask more questions, discuss and relate current issues with something they have learned in school.

> "Since 2003, I can see that the students have developed better science awareness, they are more alert. Without them realizing, they are improving. As a teacher I can see that". (C1, 36-37)

With the hands-on and minds-on experiences which they have had, participating students have enhanced their confidence in science and become convinced about their science ability. In other words, the unplanned context learning which they have experienced has affirmed their positive attitudes towards their general science acquisition.

> "As they have been exposed to outside mentors from various government and non-government sectors, they turn out to be more reasoning, confident and reliable in their actions and

decisions. They are very positive in science and excellence". (C2, 79-82)

Although not many mentors commented on their students' affections towards general science, from the views explored above, it can be found that participants become more aware of scientific phenomena and their impact on human beings. They grow to be more reasoning, confident and reliable in regard to making their own decisions. Maturity in decision-making is actually a major component in education. Their positive view of life and their ability to make their own judgements is very closely related to the intention of science education learning. Although this cannot be generalised to all participants, it is very definitely a positive signal of the success of the programme itself.

7.4.3 Teachers' views towards students' other responses

> "In conclusion, I can say that this competition maximises the potential of the student not only in science and research areas but also in time management, character building and communication skills". (G2, 79-81)

During the interviews, other responses emerged in the comments made by the teachers about their students. These other responses are grouped under the headings that teachers used when describing participants' responses. These responses emerged as a result of participation in SRBCs. Three main responses were discussed; communication skills, time-management skills and critical thinking skills. These skills are acquired indirectly and without the students realising. Accompanying the students in the classrooms and during the project indirectly enables the mentors to spot the development of the skills among the students.

i. Communication skills

Teachers' references to communication skills included students' ability to share their ideas in order to create understanding. Conveying information about a project to an audience in public is something new and challenging to students aged sixteen or seventeen. It is even more challenging when it involves a dialogue on something related to science, innovation and research. A good grasp of convincing communication skills is needed when dealing with various types of audience; adults, experts, children, non-experts and peers. In order to convince others, a student first needs to have confidence in himself/herself and then to have sound content knowledge. The skills were developed in accordance with the progress of the project, motivation and continuous practice. They are regarded as crucial especially in competitions as they act as one of the evidences of the quality of the research and the thinking involved. The better the message being conveyed, the more clearly and more logically the research would be transmitted to the audience.

> "Their confidence level is high compared with the other students. Especially for this particular poor student whom before we were a bit worried about as she had low self esteem and a lack of confidence compared with her friends. She actually developed her confidence during her participating and was able to deliver her presentation well in public and of course in class too. It was a remarkable transformation". (G2, 74-78)

This remark made by a mentor from G2 was about a shy girl who came from a poor family in a modest area of Malaysia. She and her group had been successful in being selected to compete in the international arena. From the teacher's observation, this particular participant had progressed over time. She turned out to be more confident and became an effective communicator as the programme developed. She developed a positive self-image and spoke well when presenting her project in an international competition in the following year. The transformation she showed was inspiring and promising, especially since it involved a magical change in someone who was shy by nature and who had low self-esteem.

ii. Time management

Teachers used the term ‘time management’ to refer to actions or the process of planning and exercising conscious control over the amount of time spent on accomplishing targeted activities in order to increase efficiency, productivity and effectiveness. SRBCs are intensive science programmes which involve a great deal of research and innovation. So they demand a lot of time and sacrifices from the participants and from their mentors. They need to address a few physical time-based challenges in order to complete their science research. First is the demanding residential school fixed schedule: the participants (students and mentors) need to find time in order to cope with the deadlines and the objectives of the research. Research time allocation was closely dependent on the allowance given by the school administrator. Some of the schools were very strict on the time allocations and only permitted the research to be done after school hours, but others were lenient in allowing the students to be involved in their research at any time according to their needs. Second, in addition to managing the extracurricular activities, the participants were also tied up with their academic obligations. The pressure was even greater when the participants were in the examination classes. Third, the majority of the participants were also prefects and leaders in their schools. For students in the residential school system, their commitment to the school’s discipline was an additional task which added to the overall challenges.

> “In conclusion, I can say that this competition maximized the potential of the students not only in science and research areas but also in time management, character building and communication skills”. (G2, 79-81)

In summary, the students’ ability to squeeze their time to carry out their research in their free time was acknowledged by the mentors. Determination to complete the tasks they had been set was the main driver for them to go forward to the finishing line. They allocated their free time and worked their plans according to their priorities. Their earnestness, tenacity and courage in facing this challenge gave considerable satisfaction to their teachers.

Challenging oneself to complete a project according to a tight time-table and to cope with other school responsibilities are something noble and worth looking into. Not everyone can have the drive to challenge themselves to cope with all the restrictions just to uphold the school's pride and fulfil the responsibilities. The students had to come up with strategies and contingency plans for everything that they did. Project management skills were something that they learned and experienced with their teachers' guidance and observation in response to the challenges and hurdles which they encountered. While the student participants were busy working on their projects, their mentors secretly admired their strength of persistence and their determination to do things properly. None of the participants gave up when faced with the hurdles and quit half way through. They managed to carry out their work according to their own strategic planning despite the continual challenges which arose.

> "To me, it is the skill of management. How to develop and managed time wisely. This is one of the things that will help them in real working life later. The students are already brilliant, so the most important skill they can develop is to finish whatever they have set out to do". (B1, 58-61)

The ability and the consistency which the students showed in managing their tasks are appraisable. Over the years, the teachers had witnessed much determination and persistence among the participants in managing their projects. As teachers, they were only there to assist their students when necessary; they were not allowed to become involved directly in managing their tasks and time-tables. Accordingly, the students had acquired new managerial skills; they learned how to manage the projects, their responsibilities, priorities, stress, time and anger. None of these skills were taught in the classrooms, the challenges had naturally built the skills without it being realised by either party.

These unplanned managerial skills are valuable skills developed by the participants. They will definitely help them to decide and manage other things in later life. This nurtures their maturity and trains them to be more reasoning and flexible with plans and to work a plan according to their abilities and opportunities.

iii. Critical and creative thinking skills

Teachers used the term 'critical and creative thinking skills' to describe students' abilities to generate lists of new ideas as creative and to be analytical and to make critical judgments and choices. Specifically, the abilities to think outside the norm, to identify problem statements, to identify hypotheses and construct experiments in order to prove them and to find solutions to the problems raised are categorised as being critical. Being able to come up with something to investigate is one criterion which had been used initially by mentors to identify potential participants amongst the students.

> "Each term, I will receive lots of new proposals on my desk. And I will choose the best and I will groom them from there". (B1, 30-31)

Students' creative and critical thinking blossoms with the progress of their projects. The teachers did admit that the participants had some brilliant ideas. The projects which they devised were sometimes on a par with research at university level.

> "From 2002 to 2010, I can say that the students' projects have been on a par with university research". (G2, 49-50)

Students' critical thinking, however, can sometimes not be realised due to various consequences, such as time, facilities, practical knowledge and confidence. With the mentors' help, their creativity develops and their self-efficacy towards the subject and towards science in general increases.

> “One of the participants really is a scientist; although he won bronze, he is actually able to think something which is unique and unthinkable by the teachers. Unfortunately, he doesn’t have enough time to properly develop the project. This particular student can think and use science knowledge in his innovations”. (B1, 68-71)

Unfortunately, the identified features in the participants, especially in terms of their critical thinking, were not mentioned very much by the mentors in the interviews. I wonder, therefore, whether the mentors were aware of the particular quality that their students had or whether all of the students in the schools had the same characteristic as the participants. This thought is pinpointed in a comment made by a mentor in C2:

> “The children do not have any problem as they are blessed with lots of new ideas every day”. (C2, 107-108)

In summary, residential students in general are intelligent students; they are creative and have high positive attitudes towards science as a whole. However, those chosen to be participants are those students who are not only intelligent, creative and hard-working, but who also have higher critical thinking and persistence towards whatever they undertake. Without these positive characteristics, mentoring would just be a troublesome and tiresome chore for the teachers. The students’ courage, earnestness and tenacity was definitely what fuelled the teachers’ motivation in the programme.

7.5 Teachers’ perceptions of the future of SRBCs in Malaysia

Having been experienced in mentoring students’ development in the residential schools for more than five years, the participating teachers had unique views when asked about how they perceived the opening up of opportunities to more of Malaysia’s students.

> "The students will definitely like it and will definitely participate in it. We did it in our school before. But we need to guide them. They can go further and develop interesting projects. Some of the teachers would love to help the students out". (C1, 53-56)

Having been long established in the education system, SRBCs have their enthusiastic supporters. Offering the opportunity to become involved to more students will result in more participants and consequently will involve more teachers and experts. In other words, it would become a potential major science event for Malaysia. However, there were some constraints that were raised by the teachers when they were discussing this issue, and these need to be addressed first. There were three main concerns raised; judging, mentors and the schools' unique cultures and niche interests.

i. Judging

The most important component in competitions is the judging. Every competition needs a fair and well-structured judging element. Without this main component, there would definitely be unfairness and frustration. In SRBCs, judging has been an important issue for many years. With different levels of entry and different criteria of judges, the issues are getting worse year by year.

> "It is going to be difficult to do it from the low level (such as zones); what we have now, which is the national level, is the best practice. If we do it at school level ... the judgment is different and this will jeopardize the final result". (C2, 100-102)

Probably, if the judges involved in SRBCs in Malaysia were to have special training and guidelines similar to those which the Intel International Science Engineering Fair (ISEF) has, the problems could be minimised and resolved. Some of the competitions have fixed guidelines which need to be implemented at all levels of the competition and must be monitored closely by special bodies. However, there are also a few competitions that have variable techniques in judging students' projects depending on different sets of judges. This results in dissatisfaction and inconsistent results among the contestants. If entries are measured wrongly, this negates the effort made and gives out the wrong signal to the contestants.

> "In 2008 we got first place, but that was just coincidence as not many participants really prepared for the competition. The winner won the competition without bringing any log book. That is why I said it is just faith and good luck". (B1, 13-16)

This comment was made in an interview with a teacher in B1, and clearly explains why he was upset and dissatisfied with the results, even though his school was nominated as the winner of the competition in 2008. For recording purposes, in each SRBC, the log book is the main evidence of the participants' effort and scientific explorations made throughout the period of participation. Without one, a group might be disqualified from competing in the competition. Surprisingly, in that particular year, a school without a log book won first place in the competition. So trust and confidence in the validity of the competition collapsed. That is of course not healthy for either the mentors or the participants.

ii. Mentors

The limited number of mentors available in each school restricts the number of SRBCs which a school can participate in. The interviews revealed that each capable teacher was assigned at least three projects or three competitions a year. A project will normally involve the participation of a maximum of three students. This clearly allows only a small fraction of students in a school to take part in any of the competitions. The situation is worsened if the same students represent the school for several SRBCs and when the research involves longer preparation time. This results in limited exposure for the rest of the students and increases the mentors' work-load.

> “If the number of entries each year is open, the challenge would be on the capability of the teachers to do preparation for all the teams. If there are three projects, it definitely needs the involvement of three very committed teachers. And we don’t have that much expertise in the school”. (C2, 103-106)

The teacher who made this comment then added:

> “The teacher needs to be knowledgeable; not all teachers can do innovation. It has to be related to the subject and expertise. Lots of training for the teacher needs to be provided”. (C2, 109-111)

The small amount of expertise in schools would not only reduce the quantity of the participations but also the quality of the projects. Low quality of the projects will limit the students’ experience and their exposure to scientific investigations. This would result in a waste of time and effort. The chances of winning would definitely be slim and tight. So time is wasted and a school’s reputation is jeopardised. Because of the restricted amount of participation, students need to be screened and only the fewest *crème de la crème* students will be selected to be trained and chosen to represent the school.

> “It is good idea to expand and open the entry to more students, but we need to add more mentors and facilitators too. As we can’t monitor everything, the research will be shallow. For students, it is good as it will add to their experience and enhance their research skills”. (G2, 84-88)

> “If we open the competition to all, the students will benefit and love the idea, but for the teacher it would be a problem, as it demands close mentoring and coaching”. (B1, 75-77)

All the comments, and the current situation in schools, suggest that nothing much will change as long as the administration of the competitions remains unstructured. This is because it would be difficult to increase the number of capable teachers in the time available. Furthermore, the time allocation for SRBCs could not be easily adjusted as it is fixed and changes would affect the quality of the programme. Would it be more beneficial if it is integrated into the academic syllabus which would mean allowing equal participation?

iii. A school's culture and niche interests

Residential schools each have their own unique individual culture. The school culture is formed from the niche areas which they set and which they are good at. Most of the schools are very focused on their established niche areas in order to sustain their reputation and maintain their support from the Ministry of Education. It is worth making an effort to be able to maintain their status for grants, opportunity and sustainability. Therefore, a great deal of effort has been put into only establishing these niche areas compared with the other areas. In this situation, not all residential schools are initially good at research and science, hence, not every school in the system puts the same emphasis on the programme as the others.

> "It would be more interesting if it is incorporated in the co-curriculum activities. But it is impossible as each school has its own culture. In my school, the culture is based on debating and language skills". (B1, 79-80)

With this constraint, some schools will benefit from the programme more than the rest. It would not have the same impact as some schools would easily give in in order to focus on the other areas. Teachers who are enthusiastic in the different niches of the schools will need to work harder in order to gain attention from the administration and win the students' trust in the benefit of the programme. Teachers whose interests are in science niche areas will easily get moral and financial support to help them to mentor the students' projects.

To sum up, with limited research training among the science teachers, unstructured judging methods, different school cultures, the allocation of research time in schools, and access to facilities and grants, the programme could become another burden adding to the current responsibilities held by the science teachers. The objectives of the programme will not be met because there are so many obstacles. Participation would remain at the level of just entering ‘another’ competition for the students, and would become another extra burden for the mentors.

At the national level, sadly, the issues of the unrecognised, sifted-out, talented young Malaysians will remain. After the students’ talent has been identified, they remain anonymous to the system and are soon forgotten. Therefore, not only is time, money and effort wasted, but the carefully identified young talent would be wasted too. Consequently, as has been seen from the interviews, there is no reason to increase participation in SRBCs in Malaysia unless there are serious amendments to the current programme. If only Malaysia could learn from Taiwan, Russia and the United States in appreciating young budding scientists and putting more effort into constructing the competitions, Malaysia could easily and quickly double the number of students who currently have the courage to pursue the science line streams.

7.6 Summary of the teachers’ perceptions of SRBCs in respect of their students’ responses to science

The collected views of the teachers on participation in SRBCs which have been gathered for this study have identified several interesting points which support the data gathered from the students’ input. The data from the teachers fall under four headings, and these are summarised next.

i. Teachers’ commitment and administrative support systems

There was a mixture of responses from the teachers about mentoring the projects. Some did so because of their interest in scientific research, but others did so only because they were told to do so. Accordingly, their willingness is reflected in the way they handle the challenges. Teachers' commitment to the programme is essential and has a direct bearing on the students' performance. Teachers who were interested were clearly all out for entertaining and nourishing their students' interest, while those who were not were just satisfied with accomplishing the task on time. There were also concerns about the way SRBCs are conducted; the judging criteria, extra work-load, not enough man-power and becoming burned out after years of involvement. However, not many suggestions were gathered about how to reduce these issues.

ii. Knowledge of science and scientific process

Surprisingly, just as perceived by the participants, the mentors also commented on the students' outstanding improvement in their experimental scientific skills and even in their performance in examinations. However, the teachers had discovered that there was much more increase in students' interest towards school science, especially in the research areas. Students who had participated seemed to be more confident about voicing their opinions, arguments and reasoning well on science issues. The participants appeared to be more responsible while doing science investigations and were independent about deciding what to do next. Interest in the application of science had also increased tremendously among them. They were more aware of the potential of science and could transfer school science taught in classrooms into real life. Importantly, the students had built up their interest and their confidence in pursuing science as a career.

iii. Affective responses

Not much was discussed in this area. However, the mentors did comment on the positive changes in the students' awareness of everyday science issues. They showed a positive interest in the issues related to their topic of study and reacted towards the issues positively. No particular area was mentioned specifically, but it was made clear that they paid more attention to issues related to their research areas.

iv. Other responses

There were several other responses which emerged which the teachers regarded as positive and promising in developing character among the students. Some of these were the ability to manage time, a project, stress, priorities, anger and limited facilities. There was no doubt among the teachers that students matured with the projects: they became more responsible and reasoning in whatever they were doing. If that can be regarded as developing a person as a human being, SRBCs could be claimed to be a very successful intensive programme indeed. This is because SRBCs not only test students' science capabilities but also their endurance to overcome hurdles. In other words, the capabilities of the students and of the teachers are well tested.

Chapter 8: Conclusions and Implications

Overview

This chapter presents the overall conclusions and implications of the research. It comprises four sections. The first section (8.1) addresses the main findings, which are recapitulated and re-examined in the light of the original research questions. The second section (8.2) presents the limitations of the study. It is then followed (8.3) by an assessment of the implications of the study for various agencies. The final section (8.4) makes some suggestions of possible directions for further research in the science education field.

8.1 Addressing the main findings

To recall, the overall aim of this study was to examine the impact of SRBCs on students' responses to science. There were four main questions which guided the research:

i. What responses to science are held by sixteen-year-old students in Malaysia?
ii. What are the effects of science research competitions on students' responses to science?
iii. What are the views of sixteen-year-old students of the effects on them of participating in science research based competitions?
iv. What are teachers' views of the effects of their students participating in science research based competitions?

Accordingly, the main conclusions drawn from the data collected are discussed in the context of these four questions.

8.1.1 What responses to science are held by sixteen-year-old students in Malaysia?

Sixteen-year-old students in Malaysia are studying in Form 4 at secondary school. They are in the transition stage between opting to continue to major in science or choosing to study non-science subjects instead. According to the national survey of students' responses to science conducted in 2004, Malaysian students were generally very positive about school science learning, and had considerable experience of out-of-school activities related to science and technology. They also showed positive perceptions of environmental issues and of the role of science and technology in society. The job attributes that motivated Malaysian students for their future careers included having lots of free time, working at something which is meaningful, important and creative, and earning lots of money (Yoong, 2005). Basically, students' responses to science in Malaysia were mostly positive and Malaysia ranked among the top thirty nations participating in ROSE 2004 (Yoong & Ayob, 2004).

In line with the objectives of this current study, a revised version of the 2004 questionnaire was used in this study in 2010 with a sample of sixteen-year-old students in six residential schools in the centre of Malaysia. Students in residential schools had shown stronger opinions about 'my future job', 'me and the environment', 'my opinions of science and technology' and 'my out-of-school experiences'. They aimed at jobs which are more challenging, more stimulating and potentially able to provide them with recognition in terms of dignity and respect. Furthermore, they intended to have a passion for their work which would in return lead to their creativity and ideas in inventing and designing something new being appreciated. The results of the national findings in 2004 showed that non-residential students also looked forward to enjoying jobs that provide lots of time for them to be with their families and to follow their personal interests. Interestingly, residential students were more attracted to jobs that would offer them recognition of their abilities rather than simply a good income.

In addition to their desire for something adventurous in their career undertakings, residential school students had also made more positive remarks about environmental issues; they appreciated the need for maintaining the environment as much as the actions necessary to remedy the disruption which had been caused by human activities. In addition to this, residential sixteen-year-old students had more positive attitudes towards the potential of science and technology in providing human beings throughout the country with health, safety, stability, wealth and peace. They had more positive values overall on the potential of science in their future life even though they were exposed to only limited out-of-school activities which involved nature and adventure. From the research carried out for this current study, residential students were found to be actively engaged in understanding and using the latest telecommunication innovations and technologies. They had a higher appreciation of the advancement of science and technology compared with their peers in 2004.

Interestingly, both studies identified similarly positive responses to the experiences of science which the students had in school. This indicates the uniformity of the education system in Malaysia across the systems. In other words, the residential schools' classroom learning is identical to the national classroom learning. This implies that the school syllabus, teacher training and science class settings across the nation are similar regardless of the type of school. This in turn results in the uniformity of the science learning experience and of responses to school science.

In conclusion, sixteen-year-old students in Malaysia do have very positive responses towards science, since the results of the studies show that both sets of students were very interested in science. In addition, both groups believed that science is not difficult. Nevertheless, there were some differences which emerged between the national collected data from 2004 and the data gathered from the residential schools selected for this current study in 2010. With different priority focuses and different school settings, the more able students in residential schools established more positive responses to science compared with the students in the national data. The residential school students appreciated science and scientists, creativity and innovation, and sustaining and reviving the environment just as much as their national peers in 2004 but at a higher level. Consequently, the positive responses to science held by sixteen-year-old students in residential schools in Malaysia have significant implications for Malaysia. Despite having the same science syllabus and undergoing the same curriculum, students in residential schools have more positive attitudes towards science than national students. Data gathered from the questionnaire in this current study showed that they were more into the sciences; they found science more challenging, allowing their creativity to be appreciated and inducing innovative activities. They believed in the potential contribution of science to their future undertakings and to the national well-being. This confirms the claim made in an OECD report in 2009 that students' attitudes to science are related to their performance. The participants in this study showed a positive significant difference in their interest in having jobs in science areas, in environmental issues, and in the importance of science and technology outside their school experiences compared with the findings from the national data collected in 2004. As a result, this indicates that the residential school system in Malaysia seems to have provided a conducive environment and has carefully selected suitable science exposure activities for the students to appreciate and enjoy science in their school days. It is also noticeable that the different school environments and programmes conducted result in different perceptions among the students. For this reason, it can be concluded that the difference between the science programmes taught in the national schools and those taught in the residential schools depends very much on activities outside the science classroom rather than the formal science learning in the classroom. This is very much in line with a comment made by Dale (1974) quoted in Bennett (2003) suggesting that the type of school influences the students' attitudes towards science. In the case under consideration here, it was not the type of school in terms of gender which made the difference, but the type of school in terms of whether it is residential or non-residential. This is due to the two separate learning environments and systems employed.

One of the more significant findings which emerged from this study is the similarity of interest found between national and residential school science experiences. The administrators of residential schools could be more pro-active and responsive towards the students' current needs in pursuing further activities to ensure that science continues to be more challenging and exciting for them. This would be very effective, particularly because the schools could encourage the teachers to integrate the students' creativity and science knowledge by incorporating the innovations programme with the current formal science learning. In this way, the students' enthusiasm for the progressive aspects of science would increase and perhaps would help to increase their confidence to pursue science careers later.

In summary, therefore, adding more innovative extra-curricular programmes which highlight the practical use of school science in a way which links it to what students have learned in class will encourage their interest in science and bring them meaningful experiences.

8.1.2 What are the effects of SRBCs on students' responses to science?

The students' responses to science can be divided into two; responses towards science knowledge and skills, and responses towards science in general. From the data acquired, attitudes towards school science were much more prominent compared with the latter; this is probably due to the students not being able to help themselves from associating science with the formal science learning in classrooms. By participating in science research based competitions, the students found that they were experiencing an enjoyable, meaningful period of science learning. They indicated that the knowledge used in the research was also being repeated in the classroom and *vice versa*. This resulting in strengthening their confidence, deepening their interest in science and increasing their self-efficacy in specific research subjects. This study confirmed that being exposed to first-hand information and being involved directly in the application side of knowledge had built up the students' self-assurance and confidence in regard to science. They became more confident in discussing science issues among their friends and with their teachers. This also accords with our early observations which indicated that the intensive science experimental challenges had build up their confidence and awareness in answering Paper 3 and in the science process skills as a whole.

It is accepted that SRBCs involve only a fraction of the science subjects learned in school, which allows participants to become involved in only a limited area of science, but it is not so much the content that matters to the participants, it is more the satisfaction of acquiring knowledge, satisfying their curiosity and finding the truth about things which interest them. This gives them personal fulfilment and sustains their interest in science.

In addition, working together with peers, especially on the project, was regarded as the best support system which helped students to explore, increased their confidence and led to an improvement of their communication skills in science. They were able to exchange ideas, to benefit from extra help and to discuss their science ventures openly and confidently. The collaboration which existed among them was regarded as helpful in lessening the pressure they faced and increasing their courage to proceed further, and this was regarded as comforting. The girls appreciated the moral support of their peers more than the boys. On the other hand, the boys were more pleased by the extra practical help they received from their peers.

However, students' motivation towards the projects was driven by extrinsic factors: the support which they received from their teachers and from their peers. They depended very much on the teacher's commitment: the more committed the teacher was to the project, the more motivated the students became to complete the task. This finding supports the findings from previous research conducted by Osborne and Collins (2001) and Bennett and Hogarth (2009). With committed teachers, the participants developed their knowledge and confidence in science research accordingly. On the other hand, with less-committed teachers, they became less motivated in their explorations and more readily satisfied with their progress. This current study collaborates the claims made by several scholars (Schibeci, 1984; Weinburgh, 1995; Osborne & Collins 2001; TRS, 2008; Barmby *et al.*, 2008) that teachers were found to be the most important factor in cultivating students' attitudes, while the moral and physical support of peers was regarded as motivational to them.

Nevertheless, the students cannot help but sense the pressure experienced by their teachers in struggling to manage their time in order to coach and mentor them. For those living within the residential school system, the teacher/student relationship is exceptionally close. With that understanding, the students tried their very best to please and to thank their teachers by putting all of their effort into the project. If their project wins, their teachers win too.

Experience of working with external mentors had given a positive boost to students' interest in research and science. The experience gave them satisfaction and confidence in the content knowledge, particularly in the specific areas which they researched. As a consequence of this extra help, the participants had positive views on the plausible use of science in real-life situations. Furthermore, it gave them a positive insight into the work of a scientist. Those participants who had the opportunity to work alongside their external mentors developed a strong passion and courage for venturing into a science career in their future undertakings compared with those who were not. They were also pleased when they were able to associate school science with their every day life. With such experiences, science and research made more sense to them. This finding confirms that of Sparke (1995), that there is an association between collaborating with subject experts and students' enthusiasm. In SRBCs, it is very much the case that the influence of an expert in the subject matter encourages the students' enthusiasm for the subject and consequently increases their interest in science as a whole.

In conclusion, participating in SRBCs had opened up new opportunities for the participants in the application of science. Their experiences of science were regarded as the spark to generate their positive attitude and to challenge their perspective of science to a higher level. This increased their intrinsic motivation towards the subject. However, the effects were significantly related to a number of variables such as their peers, their teachers, the degree of exposure they had (with or without the presence of external mentors) and the level of the scientific project in which they were involved. Collaborative interaction during their participation definitely increased the students' level of accomplishment, self esteem and belief in pursuing science.

Experience in SRBCs does not significantly increase content knowledge except for particular subjects which are closely related to the research area. However, with proper stimulation from teachers, from the environment and from students' own self-interest, SRBCs were thought to be able to stimulate the interest of participants in residential schools towards pursuing science with confidence, to increase their abilities and self awareness especially in carrying out practical scientific experiments, and to aid them in answering Paper 3.

In regard to science in general, the participants agreed about the positive impact that participation had on increasing their awareness towards everyday science issues. This was especially significant in the areas which they had explored during the SRBCs. With the in-depth exposure they had during the research, they were encouraged to react towards current related issues. Their interest and their awareness of the importance of science increased in proportion to their participation in SRBCs. The experience that participation gave them opened up their perspectives on specific science issues, especially on the practical application and usefulness of science in real-life situations. This also accords with observations made by Balas (1998) about participants; with the awareness they acquired from participating, the students developed their appreciation of nature and of the relevance of science in their everyday lives.

8.1.3 What are sixteen-year-old students' views of the effect on them of participating in SRBCs?

Being in residential schools where they are surrounded by high achievers, the competition amongst the students is never-ending. There are hundreds of students with various kinds of talent and background in every year group. To be selected to participate in the competitions is regarded as an honour by the students. A great deal of hard work, determination and persistence has to be put together just to be chosen to represent the school. The readiness to compete and to uphold the school's reputation in a competition is something to be taken seriously. Therefore, participants' views on their experiences are regarded as precious and meaningful to the organisers, the school administrators, their mentors and the policy makers in the Ministry of Education.

From a general point of view, the students agreed that participating had satisfied their curiosity and creativity. This was closely connected to the main reason for handling the proposal in the first place. Starting by stating a problem, they began their research step-by-step with the help of their internal and external mentors. During the process, they had encountered various challenges; internal conflict, administrative issues, conducting experiments, working with mentors and finding appropriate facilities. They had confronted their fears and curiosity with only one intention – to face the ultimate challenge of finding scientific explanations to satisfy their curiosity in order to be able present their findings at a most prestigious event.

After they had completed the competition, the students considered that participation had been the best time of their lives. They believed that they had successfully challenged themselves to the maximum by satisfying their own curiosity through their own creative efforts. The informal learning experiences which involved hands-on, minds-on activity were considered to have been enriching and enjoyable. They believed that they had been able to understand the science content better this way. However, they also stated that their excitement was more to do with the research element than with the actual science content. For that reason, they concluded that science is more exciting when it involves research.

To the participants questioned in this study, research was not limited to experiments which they conducted in the school laboratories, but was also in the exploration of something new that is linked to the science content which they had learned. Their excitement was identified as being closely related to the freedom to act, to think and to explore, or, in other words, it was autonomous learning. The minimum guidance in terms of ideas which they had received from the teachers was appreciated, but advice from experts was much sought after. The students looked forward to being able to learn from experts in particular fields and regarded the opportunity as a privilege and one of the most valuable experiences ever. They looked on the opportunity to work with professional scientists particularly in real laboratories and real research settings.

In conclusion, being accepted to participate was regarded as a precious honour by the students. Participating in SRBCs had given the participants experience of autonomous learning. Through hands-on, minds-on learning activities, they had come to regard research as the best way to enjoy science; it satisfied their curiosity and acknowledged their creativity. To them, the challenges which they encountered were worth experiencing. This is very much in line with the findings of Osborne *et al.* (2003) and of Wigfield (1995) who found that, with given tasks, students were able to satisfy their self-needs and their potential, and furthermore were enabled to evaluate challenges according to their abilities. After all, every child has his or her own capabilities, desires and dreams. The competition programme allows capable children to fulfil their desires and their dreams.

8.1.4 What are the teachers' views on the effects of their students participating in SRBCs?

As mentors who are responsible for managing and mentoring students, for locating experts, and for directly dealing with the students, the teachers who were questioned in this study had identified several significant effects of their students participating in SRBCs. They assessed students' responses based on the dialogues which they had with them, on their body language and on their written work during mentoring. Their close observations were regarded as valuable because of their years of experience in dealing with SRBCs and with student participants. Their views were valued on the students' cognitive, affective and other responses to their participation. This confirmed points which had been brought up by the students.

On the cognitive side, the teachers had identified tremendous improvements in students' confidence and awareness in carrying out practical work. They became more careful when conducting experiments, attentive about manipulating the variables and responsive to the results which they obtained. This finding is in agreement with those of Mann (1984) and Grate (1995) who also found that participation allowed students to further develop their science content knowledge, processing skills and interest in science. Furthermore, the students were more assured when answering Paper 3 questions and were more certain in explaining the procedure of experiments to their peers. In other words, they were more conscious of what they were doing and aware of the consequences of doing things wrong. The ability to think and act which was observed in this study corresponds with the findings of Tant (1992), who claimed that participating in science competitions enables the students to think and of Recht and Leslie (1988) who suggested that this enables them to make good decisions.

In science classes, students were more reasoning, quick to share and able to speak their minds clearly. They developed a confidence in engaging with others and in presenting concise and reasoned arguments. Their self-confidence developed out of their participation. However, experienced participants developed higher levels of confidence compared with first timers. Furthermore, the students' knowledge progressed with the project. They were more involved in their research areas, which allowed them to explain with confidence anything related to the study and to associate it in great detail with their everyday life experiences. Nevertheless, their confidence and knowledge were limited to the related research areas. This was inevitable given the intensive and wide exposure which they had during the preparation period. The collaboration with external experts contributed to the students' views of science overall. Indirectly they were being trained to think and act like scientists and this helped them to improve their understanding of science and opened their eyes to the possibility of real science careers.

Although participating students had about the same capabilities and potential as the rest of the students in their science classroom, their determination and passion for science was definitely above the rest. All in all, the interest and confidence in science which was initiated by the projects was regarded as something exclusive to participants. It raised their interest, their self-efficacy and their trust in doing serious scientific work in their future undertakings.

In terms of the students' affective responses, the teachers indicated that the students' alertness to and awareness of science issues improved as a result of their participation in SRBCs. They became critical in their observations especially when current science issues were involved. The students developed serious concerns about related science issues in the classrooms and always associated them to something they had learned before. This finding supports that of Bellipanny and Lili (1999) which linked participation with the ability to understand related science concepts. Positive feelings for science were developed unconsciously during the intensive research periods. Their collaborative work with external mentors contributed to the immediate development of their interest in science. They appreciated the contributions of science more and became more sensitive to how science had helped to solve various current issues.

This positive affection for science was believed by the teachers to be well developed in the participating students. Experience of conducting science research activities independently had taught them to be more reasoning and more confident about the consequences of their own actions or the decisions which they made. Furthermore, being in charge of their own projects and decisions enabled them to think about and to move with the responsibilities. Thus, students' affective reactions to science can be associated with their direct involvement with science research regardless of the level of research, the type of project or the areas of science involved.

The significant response identified by teachers was the development of communicative abilities by the students. With training they received and the challenge of conveying their research to audiences of various types in terms of age and interests, the teachers also facilitated the students in developing the ability to give a precise and understandable presentation. This involved the ability to illustrate their ideas in posters, elaborate their research verbally and document their research findings diligently. Indirectly it reflects on the students' creativity and critical thinking. The present findings are consistent with those of other studies which have found that SRBCs provide an extra learning platform on topics related to one specific interest and enable the students to demonstrate their understanding in multiple ways (Bruning *et al.*, 1995; Balas, 1998).

The students' capabilities developed with time, understanding and the maturity of the project. With good communication skills, they automatically built up their self-confidence and self-esteem. They became more sensitive when discussing science issues, especially when conveying information related to their research areas. This was regarded by teachers as a positive development amongst sixteen- to seventeen-year-old students and was reflected subsequently in the classroom.

Another important response identified by the teachers was the ability of the students in managing their time in relation to the completion of their project. Although they were committed to many academic obligations and extracurricular activities, they still managed to squeeze in time for their projects. Even though most of the students started the project very late, it was thought that they had good practice at meeting their priorities within the deadlines set. Consequently, instead of spending at least six months on a research project, they managed to complete the project in less than three months and were ready in time for the competitions. Obviously, with less time, greater effort and more pressure was involved, which tested their endurance and persistence towards the project. Although these restrictions and constraints could affect the standard of research, these circumstances provide a reliable training ground for students to be involved with pressures and with science at the same time. The zero drop-out rate proves the presence of the students' determination, earnestness and tenacity. In summary, their interest in science research projects is very obvious in their determination to meet their responsibilities. From the teachers' point of view, the students' steadfastness in completing the task is a satisfactory outcome and something that they can be proud of. This was also found in a study by Campbell (1985), in which the winners of Intel Talent Search developed skills in time management and organization which not only benefited them then at the time but also showed great promise for their future undertakings. With this courage, determination and interest in science research projects, they learn to accept responsibilities bravely.

The students' ability to learn how to conduct research in a concentrated period of time is also regarded as beneficial. It not only contributes to their confidence in answering Paper 3 but also stimulates positive interest in designing their own experiments. However, this is contrary to the conclusion of McBurney (1978) who found that making students participate is actually forcing them to use intellectual skills which may not have yet been properly developed. Subsequently, this issue has been further argued, as it has also been suggested that students develop better when they are given a proper science challenge (Mann, 1984). From the current study, it is clear that they assimilated the related content knowledge by identifying their research questions, developing hypotheses and carrying out related experimental procedures in the project. It is a fact that their science ventures in the competitions are always beyond their school science syllabus. Nevertheless, they took up the challenges as the competitions are the only opportunity for them to pursue their curiosity and set up collaborations with real scientists. To the teachers, the ability of students to think and act critically in response to the problems raised was considered a productive and enriching experience for the students and for themselves.

To sum up, teachers' views on their students' participation were positive even though teachers were not 100% committed to the programme. They evaluated the students' responses to science as high especially in terms of their courage and determination to complete the tasks. Furthermore, they were amazed by the students' ability to produce ideas and to satisfy their curiosity with only minimal observations. They believed that the students showed considerable improvement in their cognitive abilities in science and affective responses to science. Their serious engagement on the SRBCs had polished their interest in science and in research activities and revealed the talent and courage they have within themselves. Hence, it can be concluded that the teachers believed that participating in SRBCs is beneficial yet demanding for students and teachers. Students' potential in science and teachers' endurance in coping with challenges are well tested in the programme.

8.2 Contribution to knowledge

From the responses received, this study can contribute to our understanding of several aspects of knowledge of this whole issue. These can be divided into four; science competitions, the teachers' dilemma, residential school science learning and the SRBCs.

i. Science competitions

From the literature and the responses acquired in this study, competitions can be classified into two major categories (*see* Figure 3), academic and non-academic competitions. Non-academic competitions can be segregated further into two sub-categories, research based and non-research based competitions. Academic science competitions focus only on Olympiad-style competitions. These classifications were made by comparing the significant attributes and criteria by which competitions are judged. With the classifications, specific reference to the potential and the benefit of each competition can be made easily. This will lead to more academic studies of SRBCs and greater understanding of potential programmes and will enable organisers to design competitions according to the target age of competitors, students' abilities, the time available, the skills required and the specific talents which are sought.

Sponsors and interested agencies can also benefit from the classification by being able to direct their contribution to specific groups of students. This will help to segregate talents according to the requirements and open up the competitions to more students.

Moreover, the classification could also be used in various subject areas and under various guidelines for organisers and policy makers. Thus, it will open up the potential for expanding research based competitions across a whole range of knowledge.

ii. The teachers' dilemma

This study enables policy makers and school administrators to understand teachers' feelings when they are given responsibilities for mentoring students' projects. They were very supportive of the programme and dedicated to mentoring the students even though they were not able to make the fullest commitment to the programme due to the restrictions and allowances set by the administrators. By understanding this, the policy makers could adjust the timing of the competitions more appropriately and provide a flexible time frame. They could use this understanding by uniting the smaller competitions into a major national competition. Hence, more sponsors and more agencies could be encouraged to work together in searching for new talents and ideas, and a special role for a group of potential and committed key teachers could be created in each state to guide inexperienced teachers in mentoring students' projects.

Since there is no acknowledgement of teachers' long hours of mentoring and managing their students (especially in residential schools), the sponsors could reconstruct the awards which are given, probably by rewarding research experience upon winning and offering a small token to teachers for their role in advancing the research. Such innovations could lighten the burden on teachers and increase their motivation to become involved.

In summary, by understanding the problem, school administrators could be more sensitive in delegating extracurricular responsibilities to teachers, and this would encourage focus and commitment among the teachers.

iii. Residential school science learning

This study has gathered evidence on several significant issues which have never been tested in the science learning provided in residential schools; students' responses to science, their principal interest in science and the scale of their responses to school science.

From the ROSE survey, it was found that residential students had more positive attitudes towards school science and to science in general compared with national students as a whole. Residential students showed almost the same responses across the schools regardless of their gender and of the type of school (boys schools, girls schools or co-educational schools). Residential students looked for more activities which involved innovative challenges and wanted to do something which tested their creativity and intelligence. They lacked outdoor experiences, especially of field work, DIY activities and farm-related ventures. However, they were fully exposed to high-level technology and communication facilities. Hence, they were well informed on current news about the environment and related issues. Furthermore, with all this exposure, they were attracted to jobs which were able to give them satisfaction in terms of recognition and respect and which gave them the opportunity to invent and design something new.

The most significant findings were the similarity of responses reported in both studies to science learning experiences. Both types of school (national and residential) had similar attitudes to science. They enjoyed and appreciated school science learning sessions. The uniformity in their responses to learning science in school therefore indirectly indicated that the differences of studying in residential schools are in the extra-curricular activities and the latest science and technology facilities which are available to them. Also, the development of the curriculum by the Ministry has successful brought in equal opportunities and exposure in terms of school science learning for all schools in Malaysia.

iv. Science Research Based Competitions (SRBCs)

From the findings of this study, several attributes of SRBCs emerged; the differences of intentions of three types of informant, the affective responses of internal and external mentors, and students' perceptions of the programme.

The organisers and sponsors believed that SRBCs are a platform for them to fulfil their social obligations to the community. With several different intentions, they came up with various types of competition related to the different natures of their business. Some looked for 50/50 involvement – sponsoring and selling products, others wanted to advertise their products, and others sought to do business through making a social contribution to other people. Policy makers in the Ministry, however, had only one genuine intention: to send more students out to into the international arena, to claim recognition for establishing educational standards in a wider field and to increase interest in science by enabling students to observe the achievements of others. In the schools, the intention was more or less similar to that of the Ministry only on a smaller scale. They tried their best to secure a place at the national level and to receive recognition for their school's achievements. For teachers, participation was an obligation built into the job specification, and for students, it was another challenging task for them to tackle. All in all, this reveals a multitude of intentions amongst the key informants. Changes of responsible officers in the Ministry of Education will cause the programme to lose its strength and its potential to maximise students' interest in doing research. So the programme would have no specific common aim and would continue to be just another annual competition. With greater understanding of this issue, a restructuring of the organising committees is feasible and should be taken seriously with the same national intentions.

This study also identified the important role of internal mentors on students' commitment to their research. With a determined and committed internal mentor, they developed greater enthusiasm for exploring further. On the other hand, with half-hearted mentors, they seemed to be less ambitious and less motivated. The involvement of external mentors played a significant role in building their confidence. With full-scale university-type programmes, they became more motivated and more confident about their findings. But with minimum contact hours, they became confident with the content knowledge, but not sufficiently motivated. However, with no contact at all, the students were less comfortable with their findings and less motivated into pursuing science.

Finally, the students were more interested in research rather than simply in science. They appreciated science more and found it more appealing when it involved research. They hoped for more places to be available in SRBCs for their friends to enjoy research as much as they did. They recognised the role played by their mentors in the success of their projects and appreciated the opportunity which they had by participating in the programme.

8.3 Reflections on the study

This section presents reflections on the study. It comprises three main themes; things that worked well, things that might be done differently with hindsight, and the challenges which emerged and the ways in which these were overcome.

8.3.1 Things that worked well

The study gathered an adequate sample of students (n=362) at residential schools in the centre of Malaysia and consequently administered a fully acceptable ROSE questionnaire on five aspects of science experience. The questionnaire contained 137 statements (*see* Appendix D) about science and technology. This variety of enquiries resulted in a considerable richness of data, which allowed an in-depth analysis and generated a sound classification of categories. Access to such a large sample in six residential schools maximised the reliability and validity of the data which demonstrated the performance of the residential school system in cultivating science interest, as stated upon their establishment in 1963. It also enabled a comparison to be carried out with the existing national data from the survey undertaken in 2004.

The selection of schools for the study was made to represent boys, girls and co-educational schools in order to provide comparable data regarding gender influence on the effectiveness of the programme. The selection broadened the evaluation and minimised the effect associated with sample mortality when the students did not complete the questionnaire, their student diaries or interviews.

The design of the study incorporated perceptions from the three main components; key informants, teachers and students, in order to triangulate the data and permit a better understanding of the issue. Information was gathered on what were the initial aims of organising SRBCs, what preparations are involved, what benefits did the participants gain, and what were teachers' views on the programme and the effect which it had on their students. This information proved to be valuable because it integrates a collaboration of aspirations, needs and experiences into one big picture of SRBCs in Malaysia.

As well as accessing information from the three main parties from three different types of school, the study was also designed to be able to gather data in two important phases: during the preparation period and after the completion of the competitions. Students' diaries were kept and interviews were held in these two different phases. The time line designed for the study allowed the students to give an overall view of their experiences during the preparation period and to assess the conclusion of their participation two weeks after the competition. This methodology not only gathered information on the hardship, frustrations and challenges faced by the participants during the preparation period, it also highlighted the plans, insights and collective views of the SRBC programme as a whole.

The fact that the researcher had been involved in SRBC competitions for five years has given a clear direction to the research. With her practical experiences, the study reflects the story of SRBCs from the planning stage to the final implementation. This helped in determining the focus of the research, anticipating the challenges involved and setting up contacts. These experiences contributed to identifying the highlights, the insights and challenges faced by the subjects.

8.3.2 Particular challenges

One of the main limitations of this study is related to the absence of students' intentions when expressing their feelings and challenges in their diaries. This was more challenging for the boys in the boys schools compared with the girls. This consequently resulted in limited entries collected on challenges they faced weekly especially under the subheading '*explain how you solved the challenges and what you learned from them*'. This restricted the elaboration and evaluation of their responses and the conflicts which emerged during the preparation of SRBCs. Fortunately, this did not cause significant differences in students' responses towards the SRBCs as the overall responses were also backed-up by the diaries and interviews from the other schools.

The second challenge was the limited literature available on the subject. Most of the published studies were based on one-sided perceptions which focused on students' satisfaction in respect of the programme and none referred to the views of the key informants and teachers on the setting-up and the organisation of SRBCs. This under-researched area consequently took more time to design and to refine the framework. With these limitations, this study remains only a preliminary attempt to understand the issue thoroughly. However, further research on the benefits of the programme to participants (teachers, students and organisers) needs to be undertaken in depth, especially on the longitudinal development of the programme.

The third challenge was determining numbers and types of school which would be involved in the research. As the research focused on residential school students, it was crucial to select a manageable number of schools to be involved. This was because the schools were located far apart from one another, and the students were actively preparing for the same competition, which raised issues about the researcher's ability to carry out balanced observations of the students' progress and of the problems which they encountered along the seven weeks of observation (one on the pre-launch, five on project observation and one on the interviews). Therefore, it was decided to conduct the research in the central part of Malaysia. This was to ensure that equal attention could be given to all the schools, to make it feasible to monitor the students' progress and to make administering the questionnaire and the interviews manageable. As a result, only six schools which matched the fixed criteria were selected. The limited number of schools did not have any significant effect on the study as they were diverse and unique in their individual characters. Although this limitation does not allow realistic generalisation, the contribution which it makes to the understanding of SRBCs by offering a triangulated view indicates that is has a fairly good measure of sampling adequacy in the Kaiser-Meyer-Olkin test.

The fourth challenge was to involve both teachers and students in the research. With the tight time-table and long working hours which they have, it was challenging to set suitable times to hold interviews and meetings with them. Several alterations to times and venues had to be made in order to meet up with them and to interview them. Eventually, five of six schools were interviewed but the remaining school slipped through the net because the teacher declined to take part in any interviews because of her other commitments and personal obligations.

In addition to the problems described above, some of the students, especially boys, had difficulties over recording their weekly challenges in their diaries, as has been stated, and some students simply copied the challenges from a friend's diary. They could not be blamed for this as their schedule was very tight and it was not a normal practice for them to keep a journal on their daily or weekly life. With two samples of each type of school, however, these obstacles were managed, handled and accomplished. Thus, the structure of the study successfully enabled the targeted information to be assimilated from the participants.

8.3.3 Things I might do differently with hindsight

In a study of this kind, it would be ideal to have an early contact with the school administrators before carrying out the research. Early communication with teachers and students is regarded as very beneficial in setting a good rapport between all parties. It would help the researcher to understand better before the research begins the situations and the challenges which the subjects have encountered. This accordingly would help the researcher to make appropriate working plans. Acquiring insights into the students' dilemmas while carrying out the research needs to be given more attention if the study intends to focus on how the students deal with stress and with managing their determination. Using pen and paper to record their weekly challenges was found to be unexcited and uninviting. Perhaps the use of more sophisticated technological gadgets for recording their experiences would attract their attention and commitment. Various suggestions to achieve this could be by involving the internet, using a short messaging system, or perhaps an electronic diary. This links into the finding that the students were easily attracted to something trendy and hi-tech. Given their time constraints and their reluctance to describe their feelings, especially on paper, the use of technology would help to attract them (especially the boys) to participate. By means such as these, more information could be gathered and no replication of expression would be involved.

To understand the overall impact of SRBCs, it is worth investigating how student observers (non-participants) perceived participation and research in science. Being equally talented, they might also have their own views on the positive impacts of science after being surrounded by peers who have participated in competitions. This is closely aligned to the concept of learning and attitude building, where the impact could be transferred accordingly through direct involvement, observation and imagination.

Input from the non-participating science teachers in residential schools or non-residential schools would also be valuable. It would be interesting to understand their perceptions of the overall project, their evaluation of the activities experienced by their participating colleagues and their personal responses to SRBCs. There might be interesting points raised by them, especially on the opportunities to carry out research and to be involved directly with external agencies, or perhaps relief at not being selected to participate in such competitions. Their perceptions of involvement, their level of eagerness to take part in the competitions or their attitude to choosing science in their future undertakings would be interesting. Additional understanding of these areas could perhaps lead to the improvement of the focus and direction of SRBCs. It does seem beneficial to maximising the impact to a larger target audience. Consequently, this would create a clearer understanding of the investment made in SRBCs by non-participant students and teachers.

8.4 Implications of the research

This section elaborates on the implications of the study for the various agencies involved. In the light of the findings, four main implications have been identified and these will be discussed in detail in the following paragraphs.

8.4.1 Implications for policy makers

From the study, SRBCs were regarded as positive activities for the students in contributing to increasing their interest in particular subjects and building up scientific and management skills among the participants. They help to increase current interest in science, especially when it involves higher levels of understanding of current situations. With increased interest, more students would look forward to being involved in the science field. Currently, competitions, specifically SRBCs, are focused on and participated in only by top-of-the-cream students. This results in the same individuals taking part in various types of competition repeatedly, while there are other students who never have the chance to take part in any of the competitions. As a result, the programme enriches the interest of only 2% of a school's high-achieving students which is very obviously those who already have high attitudes towards science and interest in science. This is against the objectives originally set by the organisers for increasing and stimulating students into science. Initially, the investment was made to increase the number of already inspired students going into science and not to restrict science to a few top students.

As competitions are regarded as a stimulant of interest, it would be beneficial if they could be designed to stimulate various types of students with different levels of capability and different interests. Competitions could be devised in categories of challenges or perhaps different levels of difficulty. Furthermore, it would be good if they could be expanded to other subjects such as social sciences and languages. This would be a recognition of all students' different abilities and talents. After all, according to Nobel Laureate Julius Axelrod, "Ninety-nine percent of the discoveries are made by one percent of the scientists" (Terzian, 2008), so there is indeed a social pressure in preparing competitive citizens for the nation. For that reason, policy makers should address and acknowledge the interest and demands of the young on their desire to do research and should challenge them with tasks which prepare them for their future and for sustaining the national interests. In another words, preparing them to think and act ahead of time is better for their own survival.

Accordingly, there should be guidelines on the different levels of entry for competitions. There is no point in having too many competitions which target the same students as participants. In the Malaysian context, it is high time that there should be a collaborative effort to set up a National SRBC on the lines of *Intel ISEF* in the US and *Big Bang* in the UK. It could be collaboratively sponsored by all the various agencies at once. Obviously it would save the participants time and effort. In addition, more students could have the chance to participate according to their own level, and more time could be allowed for specific types of competition, enabling more students to participate and increasing the involvement of more capable judges from various universities and agencies into the same event. Such centralised competitions would minimise the burden on teachers and students in schools, as the teachers would only need to prepare and focus their students specifically for one relevant competition instead of having to manage the same project to compete in different kinds of competition organised by different agencies. This would therefore allow the students ample time to focus only on one type of competition at a time. This would result in wider recognition of inspired talents.

To sum up, policy makers need to consider the following issues:

i. Collaborative effort in organising SRB competitions

The current agencies which have sponsored or organised competitions in the same discipline should be united and enabled to work collaboratively in organising multi-level competitions which can be participated in by various levels of students. This would enhance the interest, increase the number of participants and improve knowledge transfer and self efficacy. More ideas and innovations could be shared and identified. This would not only intensify the confidence of higher achievers, it would also enhance the capabilities of intermediary achievers and increase the self-efficacy and potential of the less-capable students.

External help from outside the school should be permitted and encouraged, especially for stimulating students' curiosity about the subject and their awareness of the applicability of the knowledge to everyday issues. The stimulation of interest in the science syllabus which would be achieved is seen as more beneficial for students' general interest. This would stimulate the integration and sharing of knowledge among those who are interested and have potential. If sponsors and organisers could agree to this, the investment made in the competitions would become more beneficial to more students and to science education itself.

ii. A detailed monitoring system for the talented students

Talented and interested students who are filtered out by the competitions are an asset to the nation. They have shown their determination, passion and perseverance by participating in SRBCs. Their capabilities need to be acknowledged and nurtured in the same way as Russia, the US and Taiwan have done with their talented students. It has been proven over recent decades that doing this helps to increase the numbers of elite scientists quickly and effectively. With a proper programme and appropriate monitoring, students' interest can be moulded to fit the nation's needs. The investment in effort, finance and young talent could be used for the betterment of the nation's future especially in the areas of science and technology.

With a carefully-devised monitoring system, it would be easier to track students' development and influence them into choosing science-related careers. Furthermore, more incentives in the form of places in universities, scholarships, special programmes for young scientists or researchers and internships could be offered to them with the aim of encouraging them into science research areas. The students thus identified would become the future pool of elite scientists for Malaysia. Furthermore, with proper monitoring, the government could design a programme which suits the national needs for evaluating the progress of a programme.

iii. Science learning in residential schools

Science in residential schools is similar to that in conventional day schools. It follows the same curriculum and generates the same interest and satisfaction. This indicates that there is an equal level of exposure to science in school amongst the students in residential and in national schools. This means that the high-achieving students in residential schools have been given the same exposure to science as their peers in the national schools. With their high capabilities for learning, residential students' science learning experiences were not regarded as being as challenging as they were supposed to be. Consequently, approaches to the teaching and learning of science subjects in residential schools need to be revised. It should then be possible to incorporate more practical investigations instead of the normal pedagogy on the subject and to integrate a science research component into their co-curriculum activities. This must be done with the aim of building students' interest and providing them with as much exposure as possible to science and technology development instead of simply dictating information on science to them for the sake of an examination. Students' involvement in research could be enriching, not only for their experience of science, but also for their time management and communication skills.

iv. Enriching the knowledge of capable teachers

With the developing interest in scientific research among students, capable and committed teachers in various fields need to be given proper training in how to carry out a manageable research study with students. The research should be related to their existing subjects and syllabus and should teach them how to locate external agencies or independent bodies to help them with their inquiries. These teachers will be responsible for giving intensive and regular training to the interest group. They would also have opportunities and priority access to short courses during the school holidays in universities on research. With high-calibre teachers with access to such facilities, more students could benefit from the programme and expand their interest in research, particularly in science research.

8.4.2 Implications for school administrators

Being responsible for ensuring the sound management of the programme, the residential school administrators are directly responsible for assigning the right teacher to manage and monitor the progress of the students. The most appropriate teacher must be chosen from those who have an interest in undertaking scientific research and who have strong determination and belief in students' potential. Forcing unwilling teachers to lead teams for SRBCs will lead not only to dissatisfaction among the teachers but also frustration among the students. The research showed that teachers' enthusiasm for the programme was contagious and could influence the students' determination and drive to explore further into science. With the right choice of teacher, the programme will become a healthy platform for the school to acknowledge the students' potential in science and research, and to give recognition to the teachers' capabilities in managing and producing future talents for the nation.

It is also a part of the role of school administrators to accommodate SRBC activities by providing moral support, facilities and specific time allocations for students to be seriously involved in the activities. With appropriate facilities and the right help from related agencies, the students will be more motivated and encouraged to want to become involved in further research. Setting up an MOU with local universities and research institutions will provide better exposure for both the students and the teachers. Direct, positive contributions made by the school administrator in allowing the students to carry out their project at specific times with the help of their teachers would enable them to concentrate on and understand the project better. With better understanding, the students would have greater confidence in themselves and in conveying their research to others.

Appreciation and acknowledgment of their involvement in science activities were regarded as essential for boosting the teachers' extra contribution and students' extra commitment to participating. With such appreciation, the students in the school (participants and non-participants) would recognise the importance of the programme for the school and for the nation. Consequently, it would attract more attention and participation from all of the students. In addition, it would influence the teachers' paradigm on the importance of the programme. Therefore, more teachers would be exposed to the programme and attracted to participate in it, and eventually research will become a part of the school's culture. Ultimately, this will reshape the development of residential students' characters and make them into young people who appreciate research activities, and have confidence in pursuing them.

In the same way, with the budding interest in carrying out science research, more students will become interested in participating. Thus, school administrators could arrange their own science research classes during the extra-curricular activities. This would not only give the interested students an opportunity to develop their interest but would also give schools wider choices to select the best candidates to represent the school in inter-school competitions. With these efforts and incentives, residential students would have more opportunities for experiencing the practicality of science. They would be more occupied by and exposed to the importance of science research for the sustainability of human beings.

8.4.3 Implications for programme funders

SRBC organisers are the important agencies in charge of organising, managing and contributing to the development of interest in science research as a whole. Although they have their own specific intentions, they share a similar intention of increasing the number of students who have the interest and confidence to pursue science. However, over time, too many interested agencies have become involved who each intend to make their own social contribution by organising their own individual competition programmes. This noble intention has led to a massive number of small SRBCs each year in Malaysia. Consequently the need to make continuous preparations over a year has become a burden to both teachers and students. With the intention of winning as many competitions as possible, teachers and the students have been forced to take part in as many as they can. It would therefore be far more sensible for organisers to be united and to work together on a centralised SRBC programme. With this structure, different agencies could contribute their funds, expertise and advice to the programme. Intentionally, more students would be allowed to participate, more recognition would be given in acknowledgement of the funding given and more categories of competition could be organised. This would result in a huge, well-organised science fair, and this would attract national attention and all the hard work done would therefore receive proper acknowledgement and recognition.

By creating collaboration between all the interested parties, clearer objectives and judging strategies could be implemented. No more worries about inexperienced judges or lack of consistency in the judging strategies would arise as all of the experts from all of the national agencies would be working hand-in-hand to identify the best project of all. As a consequence, only real experts would be judging related projects. With this cooperation, more students could be allowed to take part as only one student is allowed to participate in one category of competition. So there would be no more issues about monopolising competitions or about favouritism amongst the students. This proposed development would definitely open up SRBCs to all types of school and to students of all abilities.

In addition, it would save a great deal of the effort made by teachers, students and organising companies as greater numbers of talented students could be identified in one sitting. In the long run, this would allow better structured award and recognition systems to be introduced. Consequently, it would lead to the generation of a larger potential pool of talented future elite scientists for Malaysia.

8.4.4 Implications for more widespread use of SRBC

This research study contributes to the understanding of students' responses towards participating in science research activities. Students are attracted to the programme because of the ability it will give them to understand science content knowledge actively. They like the idea of having autonomy in learning new things, especially when it involves new discoveries and science in general. The findings showed no differences between residential and non-residential students' experiences of school science, therefore more challenging activities, especially for capable students, are needed to ensure that they continue to use their ability and talent after their school days.

Students' interest in the application of science in the classroom was also noted. They appreciated the challenge and were willing to sacrifice their free time in order to participate in science research activities. By participating, they believed that they would increase their ability to appreciate the application of science learned in the classroom to their every day lives. The application of science makes some sense to their overall learning. Thus, it makes their school science more interesting and more lively. Those who were fortunate to have worked with external mentors had developed more confidence in the usefulness of science and scientists. These contacts built their self efficacy in science and changed their career aspirations to jobs related to what they had experienced. In conclusion, students' direct involvement in scientific research activities had a significant effect in determining their interest towards science and careers in science. Science appeared much more interesting to them because of their exploration and autonomous learning. Their involvement with related science external agencies brought them confidence and increased their self efficacy towards joining the field in their future undertakings.

School science is already interesting; however it would be more encouraging with the involvement of science research activities. Experience of determining the variables used and consequently making and understanding mistakes would help them to grow with science and to appreciate science more. Science learning becomes more lively and meaningful with self exploration and the involvement of research.

8.5 Further research

The study comprised a series of case studies, and responses were categorised according to the themes which emerged from the data collected. Furthermore, it is a preliminary study of its kind. Therefore, no generalisation can be made from it. Thus, it is necessary to conduct a deeper study on students' responses to their participation in SRBCs in more residential schools across Malaysia or in national schools in order to be able to make sound generalisations on the impact of SRBCs on students' responses to science. Once such generalisations can be made, a proper revision of the implementation of SRBCs in the Malaysian context could be undertaken.

The results of the study show that there was an increase of interest in science and changes in students' ambitions after they had completed SRBCs. However, it would be interesting to know the sustainability and progress of this interest over time. Would it remain for long, or will it change according to other stimuli and influences. Consequently, it would be useful if a longitudinal study of the students could be initiated and their progress towards science over time monitored closely. With this information, it would be possible to determine the strength of SRBCs in sustaining the students' interest in science and their stated determination to pursue careers in science-related areas. Would it be a temporary phase or a permanent issue for the students? And what are the factors which affect the impermanence or the sustainability of the interest?

This study used as sources a questionnaire, students' diaries and interviews. However, there was a problem over the information gathered from the students' diaries, particularly those of boys, on the shortness of the entries in response to the questions asked; they did not reveal very much elaboration of their feelings and problems. This shortcoming limited the input on the assessment of their progress from week to week. In order to have access to more reliable and more properly validated results, a medium of assessment which covers their overall attitudes towards science is needed. A study which develops and validates such a medium would be a great help in understanding the students' emotional conflicts towards various aspects of science.

As this study was based on the impact of SRBCs, particularly in terms of innovation and engineering, on students' responses to science, it is therefore necessary to look into and understand the impacts of other types of science competition on the science development of participants. A thorough study of all types of science competition would be helpful in designing customised competitions for particular subjects. In addition, a practical frame-work for all types of competition and for the end product would be an additional contribution to the science education system. Consequently, science competitions which contain challenges of varying levels of difficulty could be devised for varying levels of students' achievement and interests.

Finally, with the identified types of science competitions, more research on the impact of both types of competition would be useful. This is due to the uncertainty of their potential for encouraging, motivating and increasing students' attitudes towards science.

Appendix A

Types of Science Competitions

Type	Category	Specific Name of Competition	Age	Time (Duration)	Date of Event	Aims	Organizer / Funding	Country involves	Prizes
Applied Science	Innovation	Intel International Science Engineering Fair (INTEL ISEF) (http://www.intel.com/education/ISEF/)	14-18 (grade 9-12)	1 year (long-term project) (13 years)	May 10-15, 2009	1. to promote the understanding & appreciation of science and the vital role it plays in human advancement. 2. to inform, educate, inspire.	Intel, Society for Science and the public, corporate, academic sector, government.	50 countries	$4 millions in scholarships, tuition grants, science equipment and scientific trips, plus 70 organizations awards:. Top 3: $50,000 worth of scholarship each.
Applied Science	Innovation	Siemens Competition in Maths, Science and Technology	14-18 (grade 9-12)	1 year (long-term project)	Dec 5-8, 2009	1. to recognize remarkable talent early on 2. to foster individual growth for high school students 3. to achieve national recognition for the project completed in high school	Siemens Foundation and College Board	USA	Regional; 1st $3000 scholarship, 2nd $1000 scholarship, Final 1st: $100,000scholarship, 2nd: $50,000 scholarship.

Type	Category	Specific Name of Competition	Age	Time (Duration)	Date of Event	Aims	Organizer / Funding	Country involves	Prizes
Applied Science	Innovation	Science Expo'se Competition	14-18 (grade 9-12)	6-8 months	Aug 2008	1. to promote the value and importance of science to business, students and community 2. to foster recognition of the contributions which scientists make to our daily lives. 3. to promote science as attractive career for students 4. to strengthen scientific knowledge and expertise sharing within the state to help raise the bar of science education by providing resources, information and hands-on activities that make both the wonder and complexity of science accessible.	New South Wales Office for Science and Medical Research	Australia	AU$300 to the student Plus invitation to attend the NSW Scientist of the Year Award.
Applied Science	Innovation	Hermitage Research Station: School's Plant Science Competition (http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/4791_4235_ENA_HTML.htm)	14-18 (grade 9-12)	5 months (12 years)	May 22, 2009	1. to stimulate interest in science agriculture in young people. 2. to express to children that science is a great, long-term, rewarding career to choose.	- Dept. of Primary Industry and Fisheries, - Paul Johnson Memorial Trust	Australia	AU $1000 towards books and reference materials for first-year tertiary education, a medallion, plus 12 month subscription to a scientific journal of their choice to the value of $500.

							-The grains research foundation - State of Queensland		
Applied Science	Innovation	The Rio Tinto Big Science Competition (http://www.rtbsc.edu.au/www/index.cfm?itemid=16)	Junior, intermediate & senior	75 min (5 years)	May 3, 2009.	1. to encourage critical thinking and problem solving.	Australian Science Innovation Inc. Rio Tinto	Australian Science Innovation	Certificate of Recognition
Applied Science	Innovation	Eureka Schools Prize (http://www.amonline.net.au/eureka/go/news/2008-sleek-geeks-science-prize)	14-18 (grade 9-12)	5 months	May, 2009	1. to encourage students to have a passion for science 2. to stimulate science communication via short film project . 3. to learn something without even noticing.	- Australian Museum, - University of Sydney (Faculty of Science) -Government sectors	Australia	1st: Au $ 4000, plus $500 book voucher from Abbey's Bookshop Sydney, 2nd: $3000, 3rd: $2000
Applied Science	Innovation	Dr Nelson Ying Science competition award (http://www.yingprize.com/)	14-18 (grade 9-12)	1 year (long - term project) (10 years)	Apr, 24-26, 2009	1. to stimulate an ongoing interest in the study of science 2. to promote direct involvement of students in the process of science 3. to celebrate the exemplary science being carried out in the central Florida community	- Orlando Sc Centre (OSC) - Dr Ying	USA	US $ 5000/student $1000/ teacher, $1000/ school. $1000 to carry out further research

Type	Category	Specific Name of Competition	Age	Time (Duration)	Date of Event	Aims	Organizer / Funding	Country involves	Prizes
Applied Science	Innovation	Murder Under the Microscope (http://waterwatch.nsw.gov.au/07_murder_microscope/)	Lower secondary						
Applied Science	Innovation	Exploravision Awards http://www.exploravision.org/	14-18 (grade 9-12)	3-4 months		1. to encourage young people to explore a vision of future technology by their imaginations using the tools of science. 2. to develop higher-order thinking skills 3. to learn and to think about their role in the future	Toshiba, NSTA	USA	1st : 4 teams –saving bond with $10,000 at maturity for each student. 2nd : 4 teams- saving bond worth $ 5000 Regional prize (24 teams)- A Toshiba notebook, Honorable Mention Recognition.
Applied Science	Engineering	Intel International Science Engineering Fair (INTEL ISEF) (http://www.intel.com/education/ISEF/)	14-18 (grade 9-12)	1 year (long-term project)	May 10-15, 2009	1. to promote the understanding and appreciation of science and the vital role it plays in human advancement. 2. to inform, educate, inspire.	Intel, Society for Science and the public, corporate, academic sector, government.	50 countries	US$4 millions in scholarships, tuition grants, science equipment and scientific trips, plus 70 organizations award. Top 3: $ 50,000 worth of scholarship each.
Applied Science	Engineering	F1 *in school* (http://www.f1inschools.co.uk/page-the-f1-in-schools-challenge.html)	14-18 (grade 9-12)	1 year (long-term project) (8 years)	June, 2009	1. to help change perceptions of engineering, science and technology by creating a fun and exciting learning environment. 2. to develop an informed view about careers in engineering, Formula 1, science, marketing,techn	Formula One TM	30 countries	Scholarship in engineering

Type	Category	Specific Name of Competition	Age	Time	Date of Event	Aims	Organizer / Funding	Country involves	Prizes
Applied Science	Engineering	Future City Competition (http://www.bentley.com/en-US/Community/Academic/Student+Competitions/Future+City+2009.htm)	Lower secondary	3 months	Mar 8, 2009	1. to stir interest in science technology, engineering and maths among young people, 2. to let students present their vision of a city of the future	National Society of Profesional Engineering (NSPE) - Bently	USA	$5000 scholarship
Applied Science	Engineering	Water Rocket Competition (http://www.asme.org/Events/Contests/Ideas/Bottle_Rocket.cfm)	14-18 (grade 9-12)	3-5 months	Feb 20 2009	1. to enjoy the application of science in interesting activities. 2. to increase/ generating interest and promoting knowledge in the field of aerospace n science	Indian space Research Organization (ISRO)	India	RS 2000, RS 1500, RS1000
Applied Science	Engineering	Solar Car & Cooking With Nature (http://www.cetree.edu.my/info.asp?get=1&idkey=32)	14-18 (grade 9-12)	3 months	Oct 2009	1. to explore the potential and use of alternate energy in real life. 2. to advertise the potential use of solar power to younger generation	CETREE (Centre for education training + research and energy efficiency)	Malaysia	Certificate
Applied Science	Language	International Science Poetry Competition (http://www.scienceeducationreview.com/poetcomp.html)	Lower secondary	6 months	June 30, 2009	1. To help students to becoming creative. 2. to appreciate science in art form.	Science Education Review , Australia	Australia	Certificate and trophy

Appendix B

Interviews questions

A. Students

Purpose of the project

i. To gather the students' perceptions of SRBCs, their experiences, challenges and feelings encountered along the participation.
ii. To relate the benefits of SRBCs in nurturing responses to science among the participants

	Main Question	Points to explore
Q1	What factors influenced your participation in an SRBC?	• Volunteer/ by appointed by teachers/ peers • Interest in science/ research in particular • Intrinsic and extrinsic motivation (scholarship/ awards/ recognition/ school honour)
Q2	Has this competition helped you to understand science better? How?	• Science in classroom - the research skills/ the science process skills - creative thinking/ answering skills • Science in nature/ everyday lives - the environment issues/ science issues - science attitudes
Q3	How does participating in the competitions alter how you feel about science?	• Interesting • Meaningful • Important for human daily survival
Q4	What are your career plans at this stage? To what extent has participating in this competition affected your plans?	• Interest in science/ research • Motivating • Self confidence in pursuing into science field
Q5	What do you say about offering more SRBCs to more students in years to come? Why?	• Meaningful experience • More exposure • Knowledgeable in the application of science • More ideas
Q6	Is there anything else you would like to mention?	• Suggestion on SRBC • Comments • Etc.

B. Teachers

Purpose of the project

i. To gather the teachers' perceptions of SRBCs, their experiences, challenges and feelings encountered along the participation.
ii. To relate the benefits of SRBCs in nurturing responses to science among the participants

	Main Question	Points to explore
Q1	What factors influenced your participation in SRBC?	• Volunteering • Self interest • Appointed by the school administration
Q2	What is the most challenging task for you and your students in pursuing the competition? Why?	• Funding • Time management • Equipment • Conducting experiment/ research/ interpreting idea/ data • Presenting/ report writing • Handling date line
Q3	What steps do you take to sustain the students' motivation in their research? Why?	• Monitoring/ motivating • Seeking help from experts/ alumni/ universities • Permission • Extra attention
Q4	What effect do you think the competition has on your students' attitudes towards science?	• Pursuing into science career • Interested in the nature and science issues • Engage in scientific investigation with minimal supervision
Q4	How has this competition helped your students to understand science? Why?	• Science in classroom - the research skills/ the science process skills - creative thinking/ answering skills • Science in nature/ everyday lives - the environment issues/ science issues - science attitudes
Q5	What do you say about offering SRBCs to more students in SBP especially in years to come? Why?	• Time • Mentoring • Research experience/ science process skills • Interest in science
Q6	Is there anything else you would like to mention?	• Problem • Suggestion • Funding, etc.

C. Key informants

Purpose of the project

i. To gather the key informants' perceptions of SRBCs, their experiences, challenges and feelings encountered along the participation.
ii. To relate the benefits of SRBCs in nurturing responses to science among the participants

i. Sponsors

Parts	Questions
A	**Background Information on Science Research Based Competition (SRBC)** - When did SRBCs start in Malaysia? Internationally? - What is your role? - What are your aims in conducting and organizing the programme? - What are your responsibilities? - Who produces the original research idea? - Are there any stages in the competition? If yes, what it is? - What types of funding does your organization contribute to this type of competition? - Does the project involve a high degree of science research? - How is the students/team selection done? - What are your hopes by sponsoring students to participate in SRBCs?
B	**Conducting the programme** - What is the given time frame for each competition? - By whom and how is the monitoring of the project conducted? - Are there is any particular phases included in the completing the projects? - Is there is any involvement of external mentor/ consultant in carrying out the project? - If there is any, who will pay the fees?
C	**Experiences** - Have the participants reached the national and international competition's expectations? - Are there any trends or patterns in student's projects (2005-2009), if so, what are they? - What is the betterment initiative taken to improve the standard? - Is there is any evaluation made of the conducted activities? - Are there any particular traits that are owned by certain winning teams/schools? What are they? - What are your hopes for the next ten years? - How does involvement in SRBCs help a student's literacy in science?
D	**Others** - Is there anything else you would like to mention?

ii. **Ministry of Education**

Parts	Questions
A	**Background Information on Science Research Based Competition (SRBC)** - When did SRBCs start in Malaysia? Internationally? - What are your roles? - What are your aims in conducting and organizing the programme? - What are your responsibilities? - Who produces the original research idea? - Are there any stages in the competition? If yes, what are they? - What types of funding does your organization contribute to this type of competition? - Does the project involve a high degree of science research - How iss the students/team selection done? - What are your hopes in sponsoring students to participate in SRBCs?
B	**Conducting the programme** - What is the given time frame for each competition? - By whom and how is the monitoring of the project conducted? - Are there is any particular phases included in the completing the project? - Is there is any involvement of external mentor/ consultant in carrying out the project? - If there is any, who will pay the fees?
C	**Experiences** - Have the participants reached the national and international competition's expectations? - Are there any trends or patterns in students' projects (2005-2009), if so, what are they? - What are the betterment initiatives taken to improve the standard? - Is there is any evaluation made of the conducted activities? - Are there any particular traits that are owned by certain winning teams/schools? What are they? - What are your hopes for the next ten years? - How does involvement in SRBCs help a student's literacy in science?
D	**Others** - Is there anything else you would like to mention?

Appendix C

Permission confirmation of study

UNIT PERANCANG EKONOMI
Economic Planning Unit
JABATAN PERDANA MENTERI
Prime Minister's Department
BLOK B5 & B6
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62502 PUTRAJAYA
MALAYSIA

EPU
ECONOMIC PLANNING UNIT
PRIME MINISTER'S DEPARTMENT

Telefon : 603-8888 3333

Ruj. Tuan:
Your Ref.:

Ruj. Kami:
Our Ref.: UPE: 40/200/19/2562

Tarikh:
Date: 2 Mac 2010

Nita @ Siti Raudhah bt Amri
25 Flaxman Avenue
YO10 3TW York
North Yorkshire
United Kingdom
Email: raudhah_nita@hotmail.com

APPLICATION TO CONDUCT RESEARCH IN MALAYSIA

With reference to your application, I am pleased to inform you that your application to conduct research in Malaysia has been *approved* by the **Research Promotion and Co-Ordination Committee, Economic Planning Unit, Prime Minister's Department.** The details of the approval are as follows:

Researcher's name	:	**NITA @ SITI RAAUDHAH BT AMRI**
Passport No. / I. C No	:	**710121-10-5164**
Nationality	:	**MALAYSIAN**
Title of Research	:	**"SCIENCE RESEARCH BASED COMPETITION: THE IMPACT ON STUDENT'S ATTITUDES TOWARDS SCIENCE"**

Period of Research Approved: **1 YEAR**

2. Please collect your Research Pass in person from the Economic Planning Unit, Prime Minister's Department, Parcel B, Level 1 Block B5, Federal Government Administrative Centre, 62502 Putrajaya and bring along two (2) passport size photographs. You are also required to comply with the rules and regulations stipulated from time to time by the agencies with which you have dealings in the conduct of your research.

3. I would like to draw your attention to the undertaking signed by you that you will submit without cost to the Economic Planning Unit the following documents:

a) A brief summary of your research findings on completion of your research and before you leave Malaysia; and

b) Three (3) copies of your final dissertation/publication.

4. Lastly, please submit a copy of your preliminary and final report directly to the State Government where you carried out your research. Thank you.

Yours sincerely,

(**MUNIRAH ABD. MANAN**)
For Director General,
Economic Planning Unit.
E-mail: munirah@epu.gov.my
Tel: 88725281
Fax: 88883961

ATTENTION

This letter is only to inform you the status of your application and **cannot be used as a research pass**.

Cc:

Ketua Sektor Penyelidikan Dan Penilaian
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pelajaran Malaysia
Aras 1-4, Blok E-8
Kompleks Kerajaan Parcel E
Pusat Pentadbiran Kerajaan Persekutuan
62604 Putrajaya.

Appendix D
Questionnaire adapted from ROSE

THE UNIVERSITY of York

This booklet has questions about you, and about your experiences and interests related to science in school and outside school.

*There are **no correct or incorrect answers**, only answers that are right for you.*

*Please think carefully and give answers that **reflect your own thinking**.*

This questionnaire is being given to students in many different countries. That is why some questions may seem strange to you. If there is a question you do not understand, just leave it blank. If you are in doubt, you may ask the teacher, since this is not a test!

For most questions, you **simply put a tick in the appropriate box.**

The purpose of this questionnaire is to find out what students in Sekolah Berasrama Penuh (SBP) in Malaysia think about science at school as well as in their everyday life. This information may help us to make schools better.

Your answers are anonymous, so please, do not write your name on this questionnaire.

THANK YOU!

Your answers will be a BIG help.

START HERE:

Please tick on the relevant answer.

1. I am a ☐ girl ☐ boy

2. I am ☐ 15 yrs☐ 16 yrs

3. I am studying in __________________ (write the name of your school)

4. I ☐ have ☐ have not participated in Science Research Based Competitions

(Innovation/Engineering/ F1inschools/ Robotics/ Rocket launching/ Solar/ ______________________________)

5. I ☐ have ☐ have not won the competitions.

Contact: Prof. Dr Judith Bennett, Centre for Innovation and Research in Science Education, Department of Educational Studies, University of York, United Kingdom.

Tel: +44 (0)1094 433471, Fax: +44 (0) 1904 433444

A. My future job

How important are the following issues for your potential future occupation or job?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Not important			*Very important*
1.	Working with people rather than things	□	□	□	□
2.	Helping other people	□	□	□	□
3.	Working with animals	□	□	□	□
4.	Working in the area of environmental protection	□	□	□	□
5.	Working with something easy and simple	□	□	□	□
6.	Building or repairing objects using my hands	□	□	□	□
7.	Working with machines or tools	□	□	□	□
8.	Working artistically and creatively in art	□	□	□	□
9.	Using my talents and abilities	□	□	□	□
10.	Making, designing or inventing something	□	□	□	□
11.	Coming up with new ideas	□	□	□	□
12.	Having lots of time for my friends	□	□	□	□
13.	Making my own decisions	□	□	□	□
14.	Working independently of other people	□	□	□	□
15.	Working with something I find important and meaningful	□	□	□	□
16.	Working with something that fits my attitudes and values	□	□	□	□
17.	Having lots of time for my family	□	□	□	□
18.	Working with something that involves a lot of travelling	□	□	□	□
19.	Working at a place where something new and exciting happens frequently	□	□	□	□
20.	Earning lots of money	□	□	□	□
21.	Controlling other people	□	□	□	□

22.	Becoming famous	□	□	□	□
23.	Having lots of time for my interests, hobbies and activities	□	□	□	□
24.	Becoming 'the boss' at my job	□	□	□	□
25.	Developing or improving my knowledge and abilities	□	□	□	□
26.	Working as part of a team with many people around me	□	□	□	□

B. **Me and the environmental challenges**

To what extent do you agree with the following statements about problems with the environment (pollution of air and water, overuse of resources, global changes of the climate etc.)?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Disagree			*Agree*
1.	Threats to the environment are not my business	□	□	□	□
2.	Environmental problems make the future of the world look bleak and hopeless	□	□	□	□
3.	Environmental problems are exaggerated	□	□	□	□
4.	Science and technology can solve all environmental Problems	□	□	□	□
5.	I am willing to have environmental problems solved even if this means sacrificing many goods	□	□	□	□
6.	I can personally influence what happens with the environment	□	□	□	□
7.	We can still find solutions to our environmental problems	□	□	□	□
8.	People worry too much about environmental problems	□	□	□	□
9.	Environmental problems can be solved without big changes in our way of living	□	□	□	□
10.	People should care more about protection of the environment	□	□	□	□
11.	It is the responsibility of the rich countries to solve the environmental problems of the world	□	□	□	□
12.	I think each of us can make a significant contribution to environmental protection	□	□	□	□
13.	Environmental problems should be left to the experts	□	□	□	□

14.	I am optimistic about the future	□	□	□	□
15.	Animals should have the same right to life as people	□	□	□	□
16.	It is right to use animals in medical experiments if this can save human lives	□	□	□	□
17.	Nearly all human activity is damaging for the environment	□	□	□	□
18.	The natural world is sacred and should be left in peace	□	□	□	□

C. My science classes

To what extent do you agree with the following statements about the science that you may have had at school?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Disagree			*Agree*
1.	School science is a difficult subject	□	□	□	□
2.	School science is interesting	□	□	□	□
3.	School science is rather easy for me to learn	□	□	□	□
4.	School science has opened my eyes to new and exciting jobs	□	□	□	□
5.	I like school science better than most other subjects	□	□	□	□
6.	I think everybody should learn science at school	□	□	□	□
7.	The things that I learn in science at school will be helpful in my everyday life	□	□	□	□
8.	I think that the science I learn at school will improve my career chances	□	□	□	□
9.	School science has made me more critical and sceptical	□	□	□	□
10.	School science has increased my curiosity about things we cannot yet explain	□	□	□	□
11.	School science has increased my appreciation of nature	□	□	□	□
12.	School science has shown me the importance of science for our way of living	□	□	□	□
13.	School science has taught me how to take better care of my health	□	□	□	□
14.	I would like to become a scientist	□	□	□	□
15.	I would like to have as much science as possible at school	□	□	□	□
16.	I would like to get a job in technology	□	□	□	□

D. **My opinions about science and technology**

To what extent do you agree with the following statements?

(Give your answer with a tick on each row. If you do not understand, leave the line blank.)

		Disagree			*Agree*
1.	Science and technology are important for society	◻	◻	◻	◻
2.	Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	◻	◻	◻	◻
3.	Thanks to science and technology, there will be greater opportunities for future generations	◻	◻	◻	◻
4.	Science and technology make our lives healthier, easier and more comfortable	◻	◻	◻	◻
5.	New technologies will make work more interesting	◻	◻	◻	◻
6.	The benefits of science are greater than the harmful effects it could have	◻	◻	◻	◻
7.	Science and technology will help to eradicate poverty and famine in the world	◻	◻	◻	◻
8.	Science and technology can solve nearly all problems	◻	◻	◻	◻
9.	Science and technology are helping the poor	◻	◻	◻	◻
10.	Science and technology are the cause of the environmental problems	◻	◻	◻	◻
11.	A country needs science and technology to become developed	◻	◻	◻	◻
12.	Science and technology benefit mainly the developed countries	◻	◻	◻	◻
13.	Scientists follow the scientific method that always leads them to correct answers	◻	◻	◻	◻

14.	We should always trust what scientists have to say	□	□	□	□
15.	Scientists are neutral and objective	□	□	□	□
16.	Scientific theories develop and change all the time	□	□	□	□

E. My experiences of science outside science lessons
How often have you done this outside science lessons?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

	I have ...	*Never*			*Often*
1.	tried to find the star constellations in the sky	□	□	□	□
2.	read my horoscope (telling future from the stars)	□	□	□	□
3.	read a map to find my way	□	□	□	□
4.	used a compass to find direction	□	□	□	□
5.	collected different stones or shells	□	□	□	□
6.	watched (not on TV) an animal being born	□	□	□	□
7.	cared for animals on a farm	□	□	□	□
8.	visited a zoo	□	□	□	□
9.	visited a science centre or science museum	□	□	□	□
10.	milked animals such as cows, sheep or goats	□	□	□	□
11.	made dairy products like yoghurt, butter, cheese or ghee	□	□	□	□
12.	read about nature or science in books or magazines	□	□	□	□
13.	watched nature programmes on TV or in a cinema	□	□	□	□
14.	collected edible berries, fruits, mushrooms or plants	□	□	□	□
15.	participated in hunting	□	□	□	□
16.	participated in fishing	□	□	□	□
17.	planted seeds and watched them grow	□	□	□	□
18.	made compost of grass, leaves or garbage	□	□	□	□
19.	made an instrument (like a flute or drum) from natural materials	□	□	□	□
20.	knitted, weaved, etc	□	□	□	□
21.	put up a tent or shelter	□	□	□	□
22.	made a fire from charcoal or wood	□	□	□	□
23.	prepared food over a campfire, open fire or stove burner	□	□	□	□

		Never			Often
24.	sorted garbage for recycling or for appropriate disposal	□	□	□	□
25.	cleaned and bandaged a wound	□	□	□	□
26.	seen an X-ray of a part of my body	□	□	□	□
27.	taken medicines to prevent or cure illness or infection	□	□	□	□
28.	taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.)	□	□	□	□
29.	been to a hospital as a patient	□	□	□	□
30.	used binoculars	□	□	□	□
31.	used a camera	□	□	□	□
32.	made a bow and arrow, slingshot, catapult or boomerang	□	□	□	□
33.	used an air gun or rifle	□	□	□	□
34.	used a water pump or siphon	□	□	□	□
35.	made a model such as toy plane or boat etc	□	□	□	□
36.	used a science kit (like for chemistry, optics or electricity)	□	□	□	□
37.	used a windmill, watermill, waterwheel, etc	□	□	□	□
38.	recorded on video, DVD or tape recorder	□	□	□	□
39.	changed or fixed electric bulbs or fuses	□	□	□	□
40.	connected an electric lead to a plug etc.	□	□	□	□
41.	used a stopwatch	□	□	□	□
42.	measured the temperature with a thermometer	□	□	□	□
43.	used a measuring ruler, tape or stick	□	□	□	□
44.	used a mobile phone	□	□	□	□
45.	sent or received an SMS (text message on mobile phone)	□	□	□	□
46.	searched the internet for information	□	□	□	□
47.	played computer games	□	□	□	□
48.	used a dictionary, encyclopaedia, etc. on a computer	□	□	□	□

49.	downloaded music from the internet	□	□	□	□
50.	sent or received e-mail	□	□	□	□
51.	used a word processor on the computer	□	□	□	□
52.	opened a device (radio, watch, computer, telephone, etc.) to find out how it works	□	□	□	□
53.	baked bread, paste, cake, etc	□	□	□	□
54.	cooked a meal	□	□	□	□
55.	walked while balancing an object on my head	□	□	□	□
56.	used a wheelbarrow	□	□	□	□
57.	used a crowbar (jemmy)	□	□	□	□
58.	used a rope and pulley for lifting in heavy things	□	□	□	□
59.	mended a bicycle tube	□	□	□	□
60.	used tools like a saw, screwdriver or hammer	□	□	□	□
61.	charged a car battery	□	□	□	□

Appendix E

Students' diary

Reflective Journal	**Date/ Time:**

Date	What are the challenges encountered? *(E.g. training, experiment, research, writing)*	How do you solve the problems and what are the lesson learned? *(E.g. consulting expert, repeat the experiment, talk to mentor, peers, etc)*	How do you feel about the project at this stage? *(E.g. Confident, give-up, fed-up, etc)*	How do you feel about your self/ mentor/ peers/ teachers at this stage? *(E.g. motivation, disappointed, happy, etc)*	What are your actions plans for next week? *(E.g. future development, points to work on or maintain and how)*

Appendix F

Interview Schedule

Summary of the questionnaire and interview schedule for students and teachers, 2010

Schools	Date	Activity	Logistic
B1	23 March, 2010	1. Attitudes to Science Test Distribution & Administration. 2. Briefing on Logbook entry to 2 students	1. 35 minutes for questionnaire answering 2. 15 minutes briefing
	10 May, 2010	1. Student interviews 2. Teacher interview	Teacher interview (1.30-2.15 pm) Student interviews (3.30- 4.45)
B2	22 March, 2010	1. Attitudes to Science Test Distribution & Administration. 2. Briefing on Logbook entry to 2 students	1. 35 minutes for questionnaire answering 2. 15 minutes briefing
	11 May, 2010	1. Student interviews 2. Teacher interview	Teacher interview (1.30-2.15 pm) Student interviews (3.30- 4.45)
G1	23 March, 2010	1. Attitudes to Science Test Distribution & Administration. 2. Briefing on Logbook entry to 2 students	1. 35 minutes for questionnaire answering 2. 15 minutes briefing
	12 May, 2010	1. Student interviews 2. Teacher interview	Teacher interview (1.30-2.15 pm) Student interviews (3.30- 4.45)
G2	22 March, 2010	1. Attitudes to Science Test Distribution & Administration. 2. Briefing on Logbook entry to 2 students	1. 35 minutes for questionnaire answering 2. 15 minutes briefing
	13 May, 2010	1. Student interviews 2. Teacher interview	Teacher interview (1.30-2.15 pm) Student interviews (3.30- 4.45)
C1	24 March, 2010	1. Attitudes to Science Test Distribution & Administration. 2. Briefing on Logbook entry to 2 students	1. 35 minutes for questionnaire answering 2. 15 minutes briefing
	15 May, 2010	1. Student interviews 2. Teacher interview	Teacher interview (1.30-2.15 pm) Student interviews (3.30- 4.45)

C2	25 March, 2010	1. Attitudes to Science Test Distribution & Administration. 2. Briefing on Logbook entry to 2 students	1. 35 minutes for questionnaire answering 2. 15 minutes briefing
	16 May, 2010	1. Student interviews 2. Teacher interview	Teacher interview (1.30-2.15 pm) Student interviews (3.30- 4.45)

Appendix G

A: "My future job"

	Responses (%)				
	Not at all important	Not so important	Important	Very important	No response
15. Working with something I find important and meaningful	1.1	4.4	21	**72.9**	0.6
25. Developing or improving my knowledge and abilities	0.8	1.7	14.6	**82.3**	0.6
16. Working with something that fits my attitudes and values	1.9	6.1	21.8	**70.2**	0
17. Having lots of time for my family	1.4	5	23.8	**69.9**	0
23. Having lots of time for my interests, hobbies and activities	5.5	15.5	30.7	**47.5**	0.8
19. Working at a place where something new and exciting happens frequently	4.4	11.9	30.1	**53.3**	0.3
8. Working artistically and creatively in art	18	26	24.6	**31.5**	0
10. Making, designing or inventing something	6.9	13	32.6	**47.2**	0.3
6. Building or repairing objects using my hands	15.5	**29.8**	27.9	26.5	0.3
7. Working with machines or tools	16	15.7	33.1	**34.5**	0.6
24. Becoming 'the boss' at my job	16	19.1	27.3	**37.6**	0.6
21. Controlling other people	29.6	**35.9**	20.7	13.3	0.3
22. Becoming famous	**34.3**	26	24.3	15.2	0.3
3. Working with animals	32.9	**33.1**	21.8	10.8	1.4
2. Helping other people	1.7	3.6	22.7	**72.1**	0
11. Coming up with new ideas	3.6	7.5	21.5	**67.4**	0
5. Working with something easy and simple	8.3	14.1	32.6	**44.2**	0.8
4. Working in the area of environmental protection	4.7	9.4	30.9	**54.4**	0.6
12. Having lots of time for my friends	2.8	19.1	33.7	**44.2**	0.3
9. Using my talents and abilities	1.9	3.3	20.2	**74.6**	0
20. Earning lots of money	3.6	8.6	24	**63.8**	0
13. Making my own decisions	3.3	11	35.9	**49.4**	0.3
14. Working independently of other people	7.2	19.9	**40.3**	30.7	1.9
18. Working with something that involves a lot of travelling	10.2	17.1	32.6	**39.5**	0.6
26. Working as part of a team with many people around me	2.8	5	23.8	**68**	0.6
1. Working with people rather than things	5.3	12.4	**43.9**	34.3	4.1

B. “'Me and the environment'

	Responses (%)				
	Strongly Disagree	Disagree	Agree	Strongly Agree	No response
10. People should care more about protection of the environment	1.1	4.1	12.2	**81.2**	1.4
7. We can still find solutions to our environmental problems	2.2	5.5	22.7	**67.7**	1.9
12. I think each of us can make a significant contribution to environmental protection	1.9	3.9	20.7	**69.6**	3.9
15. Animals should have the same right to life as people	8.0	11.9	20.4	**57.7**	1.9
18. The natural world is sacred and should be left in peace	2.2	9.7	25.4	**59.7**	3.0
5. I am willing to have environmental problems solved even if this means sacrificing many goods	9.1	15.7	**39.2**	33.7	2.2
17. Nearly all human activity is damaging for the environment	6.4	11.6	34.0	**46.7**	1.4
14. I am optimistic about the future	5.5	12.7	31.8	**47.2**	2.8
8. People worry too much about environmental problems	**28.7**	28.2	18.8	22.1	2.2
1. Threats to the environment are not my business	**72.1**	13.5	7.2	6.1	1.1
11. It is the responsibility of the rich countries to solve the environmental problems of the world	24.3	22.9	22.1	**29.3**	1.4
13. Environmental problems should be left to the experts	**55**	26	9.9	7.7	1.4
4. Science and technology can solve all environmental problems	11.0	20.4	**37.3**	29.6	1.7
2. Environmental problems make the future of the world look bleak and hopeless	6.4	6.9	12.4	**73.5**	0.8
3. Environmental problems are exaggerated	11.6	14.6	28.2	**29.3**	16.3
9. Environmental problems can be solved without big changes in our way of living	**33.7**	19.9	24.3	20.2	1.9
6. I can personally influence what happens with the environment	9.9	24.0	**35.4**	22.9	7.7
16. It is right to use animals in medical experiments if this can save human lives	15.5	24.3	27.9	**30.4**	1.9

C: "My Science Classes"

	Responses (%)				
	Strongly Disagree	**Disagree**	**Agree**	**Strongly Agree**	**No response**
13. School science has taught me how to take better care of my health	1.7	5.0	23.5	**68.2**	1.7
7. The things that I learn in science at school will be helpful in my everyday life	1.9	3.3	21.0	**72.9**	0.8
11. School science has increased my appreciation of nature	2.2	3.9	21.0	**62.4**	2.8
6. I think everybody should learn science at school	6.4	7.2	28.7	**64.4**	1.1
8. I think that the science I learn at school will improve my career chances	3.0	2.8	20.2	**73.2**	0.8
10. School science has increased my curiosity about things we cannot yet explain	2.2	7.5	29.0	**58.8**	2.5
4. School science has opened my eyes to new and exciting jobs	1.7	6.4	25.4	**65.7**	0.8
12. School science has shown me the importance of science for our way of living	2.2	4.4	21.3	**70.7**	1.4
3. School science is rather easy for me to learn	9.9	22.9	**41.2**	25.1	0.8
2. School science is interesting	1.9	7.2	26.0	**64.1**	0.8
5. I like school science better than most other subjects	9.7	22.9	32.3	**33.7**	1.4
15. I would like to have as much science as possible at school	16.6	27.9	**29.3**	24.9	1.4
1. School science is a difficult subject	24.9	29.0	29.3	16.0	0.8
9. School science has made me more critical and sceptical	14.4	21.3	**32.3**	28.5	3.6
16. I would like to get a job in technology	14.1	14.1	27.3	**42.5**	1.7
14. I would like to become a scientist	**31.2**	22.4	24.9	19.9	1.7

D: 'My opinions of science and technology'

	Responses (%)				
	Strongly Disagree	Disagree	Agree	Strongly Agree	No response
1. Science and technology are important for society	2.2	3.0	16.6	**76.5**	1.7
3. Thanks to science and technology, there will be greater opportunities for future generations	2.5	1.4	17.7	**76.8**	1.7
2. Science and technology will find cures for diseases such as HIV/AIDS, cancer, and so on.	1.4	1.9	17.7	**77.6**	1.4
4. Science and technology make our lives healthier, easier and more comfortable	1.9	3.3	23.2	**69.9**	1.7
5. New technologies will make work more interesting	2.8	4.7	16.0	**74.6**	1.9
11. A country needs science and technology to become developed	1.4	3.9	28.7	**63.8**	2.2
6. The benefits of science are greater than the harmful effects it could have	6.4	14.4	**39.5**	36.7	3.0
7. Science and technology will help to eradicate poverty and famine in the world	6.4	11.6	**40.1**	28.5	13.5
8. Science and technology can solve nearly all problems	8.3	19.3	**39.8**	30.7	1.9
9. Science and technology are helping the poor	14.1	26.8	**33.1**	23.8	2.2
12. Science and technology benefit mainly the developed countries	3.0	4.7	35.1	**54.7**	2.5
13. Scientists follow the scientific method that always leads them to correct answers	3.9	13.3	39.5	**40.1**	3.3
14. We should always trust what scientists have to say	11.0	22.9	**40.9**	22.7	2.5
15. Scientists are neutral and objective	25.1	**34.8**	24.3	14.1	1.7
16. Scientific theories develop and change all the time	5.5	14.9	37.0	**40.1**	2.5
10. Science and technology are the cause of environmental problems	11.9	26.2	**32.0**	27.9	1.9

E: 'My out of the science classroom experiences'

	Responses (%)				
	Never	**Seldom**	**Often**	**Always**	**No response**
39. Changed or fixed electric bulbs or fuses	23.5	25.4	**27.3**	19.9	3.9
40. Connected an electric lead to a plug etc.	17.4	21.5	24.0	**33.4**	3.6
60. Used tools such as a saw, screwdriver or hammer	5.5	23.2	**35.4**	34.0	1.9
52. Opened a device (radio, watch, computer, telephone, etc.) to find out how it works	12.2	18.5	20.7	**45.3**	3.3
22. Made a fire from charcoal or wood	21.8	**25.4**	31.2	19.6	1.9
21. Put up a tent or shelter	13.3	24.6	**37.8**	22.7	1.7
14. Collected edible berries, fruits, mushrooms or plants	**33.4**	29.0	19.9	16.3	1.4
23. Prepared food over a campfire, open fire or stove burner	16.6	25.4	**32.6**	22.9	2.5
25. Cleaned and bandaged a wound	11.3	25.1	**34.5**	27.3	1.7
17. Planted seeds and watched them grow	16.9	26.8	**34.0**	20.7	1.7
5. Collected different stones or shells	19.9	**30.9**	27.6	19.9	1.7
59. Mended a bicycle tube	**33.4**	29.6	18.2	14.9	3.9
50. Sent or received e-mail	6.6	8.6	15.7	**67.1**	1.9
49. Downloaded music from the internet	6.9	8.6	13.3	**69.6**	1.7
46. Searched the internet for information	2.2	4.1	15.2	**76.0**	2.5
51. Used a word processor on the computer	6.1	13.5	26.5	**49.7**	4.1
47. Played computer games	4.7	7.5	16.3	**69.6**	1.9
44. Used a mobile phone	2.5	3.9	11.6	**80.4**	1.7
45. Sent or received an SMS (text message on mobile phone)	3.0	4.4	10.2	**80.7**	1.7
48. Used a dictionary, encyclopaedia, etc. on a computer	3.6	11.0	25.7	**57.7**	1.9
32. Made a bow and arrow, slingshot, catapult or boomerang	**49.7**	25.4	12.7	8.0	4.1
16. Participated in fishing	**43.1**	21.0	17.4	18.5	0
61. Charged a car battery	**58.8**	19.1	8.8	11.3	1.9

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