# Evaluating the Impact of Individual and Collective Electronic Games on Mathematical Learning Achievement in Primary School

**Rabab Alsaffar**

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**University of York**

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## Abstract

This thesis describes research that aimed to assess the impact of Educational Electronic Games (EEG) on mathematics learning in primary schools when learning takes place on an individual or collective basis, and make suggestions to enhance learning effectiveness. The context was primary education in Kuwait in 5th grade (age 9 to 10 years) and the course of study was mathematics. The purpose of the research was to investigate whether the initiative of the Kuwaiti government in promoting the use of EEG on a large scale was worthwhile and to make recommendations to enhance learning through EEG, if necessary.

The literature review indicated the research gaps in terms of student learning outcome achievement and teachers' perceptions about the success of EEG in both the individual and collective mode. A mixed methods approach using both qualitative and quantitative techniques was adopted. The quantitative techniques involved descriptive statistics, and inferential statistics in the form of hypothesis testing. A sample of 74 students and 124 teachers was chosen based on the standard sample size formula for a finite population. The student data in the form of a performance test were used to assess learning outcome achievement and the teacher data, obtained through a questionnaire survey, were used to study their perceptions about the success of EEG. The school was chosen based on the representativeness of the sample's characteristics. Qualitative techniques included observations made during student participation in individual and collective EEG, a questionnaire survey of teachers, and two semi-structured interviews.

The study revealed that EEG had a significant influence on the achievement of the learning outcome and permanency of learning; that the collective mode of EEG was superior to the individual mode; and that gender difference had no influence on learning outcome achievement or permanency of learning. The success of EEG usage, according to the perceptions of the teachers, was dependent on the teacher characteristics and the teachers were relatively positive about the success of EEG usage in both the individual and collective

mode. The recommendations made to the Ministry of Education included an emphasis on the selection criterion of teachers at the entry level based on teacher characteristics such as: computer education, higher educational qualifications, and the type of EEG to which the teachers were exposed; and it was also recommended that characteristics such as age, gender, designation, teaching experience, and courses taught by the teachers may be given lower importance, as these had no major bearing on their perceptions about the success of EEG usage.

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Finally, I thank my parents for their unstinting support to my research from the beginning till the end.

## Author's Declaration

I hereby declare that the work presented in this thesis entitled **"Evaluating the Impact of Individual and Collective Electronic Games on Mathematical Learning Achievement in Primary School"** has been carried out by me at The University of York, under the supervision of Dr. Peter Rudd. The present work has not formed the basis for the award of any other degree, diploma or fellowship from any other University previously. The work is my own, except where referenced. The particulars given in this thesis are true to the best of my knowledge and belief.

# CHAPTER 1

# Introduction

## 1.1. Aim of the study and the Rationale

The aim of the research is to assess the impact of Educational Electronic Games (EEG) on mathematics learning in primary school, when learning takes place on an individual and collective basis, and make suggestions to enhance learning effectiveness through EEG. In most generic term a game is a process in which one or two players participate either through physical or mental activity with the aim of scoring higher points than the opponent (in one player game it could be computer) and when this feature is combined with learning it can infuse additional energy to participate, spark innovation and creativity in the learner, and promote divergent or 'out of the box' thinking (Fuszard, 2001).

The rationale of the study lies in the verification of the findings revealed through the literature review that there are 'soft' aspects to learning, such as the psychological and cognitive elements, which have a bearing on the ability to create an interest in learning, influence the attitude, and vary the motivational state of the student; EEG has the potential to influence these soft aspects. The existing support literature is mainly theoretical and the studies which have provided empirical evidence to support the fact that EEG has the ability to enhance learning tend to be based on the Western world experiences. No concrete studies have been carried out in an Arab context, that has a different socio-cultural setting. Moreover, very little research has been conducted to test if the influence of EEG varies when the children learn on an individual or a collective basis and the influence of gender difference on learning is also less explored.

It is well-established that, while learning mathematics, irrespective of whether an individual or collective approach is used, there are four aspects which need to be considered. The first is to understand the rules of mathematics (cognizance), the second is to memorize what is important such as multiplication tables (comprehension), the third is to be able to apply the relevant rules in a new situation (application), and finally the fourth is to retain the knowledge learnt for a longer duration of time (permanency). The proponents of EEG claim that all of these steps are made easier and interesting through EEG, and this research seeks to verify if this claim is true empirically through direct observation, the perception of teachers and students, and a quantitative analysis of the results obtained through the usage of EEG on both an individual and collective basis. The outcome will lead to the development of an understanding of whether or not EEG significantly impacts on the learning of mathematics in the context chosen.

The socio-cultural setting of the Arab world is very different from that of the Western world, particularly when it comes to gender difference. Not all schools in the Arabic states are coeducational or in a social setting, and the gender mix is also an issue, as pointed out by several researchers (Kinzie and Joseph, 2008; Annetta, Mangrum, Holmes, Collazo and Cheng, 2009; Lowire and Jorgensen, 2011; Abdu-Raheem, 2012). So, the rationale also considers the influence of gender difference while learning through EEG.

Three major objectives were to be accomplished in this resesarch. The first was to investigate whether EEG usage significantly improved learning outcome achievement and permanency of learning and also whether the outcome achievement differed with respect to gender. The second was to determine whether EEG usage in the individual and collective modes had a significantly different effect on the achievement of learning outcomes and permanency of learning. The third objective was to study the perceptions of the teachers about the success of EEG and determine whether teacher characteristics influenced these perceptions.

The research origin is linked to the extensive research which is in progress round the globe on the usage of computers and electronic gadgets in primary education to enhance performance. These studies focus on two main issues of concern. First, they are mainly based in Western settings and so cannot be completely generalized to settings in rest of the world because of the disparity in terms of social, cultural and economic background. Second, the research so far is inconclusive about whether the usage of EEG or any other technology based learning improves the achievement of learning outcomes significantly for any courses taught in primary education. While one school of thought claims that technology can only add entertainment value through colour, animation, and sound, without offering any additional learning value (Busch, 2014; Perrotta et al., 2013; Kim and Chang, 2010; Fengfeng, 2008; Ke, 2008; and Asplin et al., 2006) another school of thought claims that there is evidence of improved learning as, the more the students are motivated towards learning through these gadgets, the better will be their performance (Yang et al., 2013; Al-Harby, 2010; Dickey, 2010; Burguillo, 2010; Gillispie, 2008; Akinsola, 2007; Ebner & Holzinger, 2007; Ke & Grabowski, 2007; Oblinger, 2006; Gee, 2005 and Rosas et al., 2003). So, there is a need to investigate further the impact of EEG on learning outcome achievement. There are two aspects which can influence learning outcome achievement: the student's interest in learning and the teacher's ability to facilitate learning, particularly in the context of primary schools, so both of these aspects have to be considered in order to assess learning outcome achievement. The students' performance is directly measurable through testing knowledge, skills, and attitude development through learning a topic, whereas the teacher's role is attributed to the teacher characteristics (Kosgei et al., 2013). Among the various teacher characteristics listed by a group of researchers, in this research, seven characteristics were chosen owing to their relevance to primary education teaching: educational qualifications, age, gender, designation, experience, course taught, and type of game used.

The research strategy adopted in this research was the mixed methods approach, with primary data being collected from the students as well as the teachers. The research paradigm used was empiricism with a positivist approach to research which assumes that *a priori* knowledge is available and it should be observed through experimentation to seek relationships between the variables of research interest. The research design included sampling and a questionnaire survey for the quantitative component of the research and questionnaire survey and semi-structured interviews for the qualitative component. The students provided quantitative primary data to verify whether EEG-based learning in the individual and collective modes would contribute to the improved achievement of learning outcomes and also to study the influence of gender difference on outcome achievement. The outcome achievement in learning was assessed through the scores on performance tests conducted on the students on a pre- and post-test basis. A completely randomized experimental design was used to collect the primary quantitative data. A Likert 5-point scale was used to collect the quantitative data from the teachers via a questionnaire survey, and open-ended questions were used to collect the qualitative information. The sample size estimation was performed using the standard formulae, which yielded a sample size of 74 students and 124 teachers. The students comprised a randomly chosen group of 5$^{th}$ grade (aged 9 to 10 years) male and female students from different sections. The sample comprised 42 males and 32 female students chosen via a random sampling basis. The Lottery method was adopted for the randomization of the students from the student list of the class. To conduct the experiment with the student group, the 74 students were divided equally and subjected to both the individual and collective modes of EEG-based learning. The school selection was through a representative sample based on convenience sampling.

The data analysis in the quantitative component was through descriptive statistics which included skewness, kurtosis, mean, standard deviation and percentage calculations with respect to the degree of agreement with the indicators of the questionnaire; and inferential statistics which was basically through hypothesis testing through t-tests and analysis of variance (ANOVA). The qualitative analysis is analysed through rationalizing and screening the information provided by the respondents as appropriate to the research questions. The information is also linked to the findings using quantitative techniques to check whether any agreement exists, particularly in the context of hypothesis testing. Some insightful and stimulating experiences shared by the teachers have been used to support the association between the research variables as observed through the hypothesis testing.

This research makes a significant contribution to the body of knowledge in educational research with specific reference to EEG-based learning through the production of new empirical findings. First of all, it has established conceptual linkages between learning outcome achievement and permanency of learning and EEG-based learning in individual and collective modes. Then, it has empirically validated the relationships between these research variables through experimentation in a real life situation in a primary school. The specific contributions include the provision of empirical proof of the significance of relationships between: learning through individual and collective EEG with the academic achievement of learners and the permanency of learning; the differential effect produced by learning through individual and collective EEG with the academic achievement of the learner and the permanency of learning; the effect of the gender of the students on the academic achievement of the learner and the permanency of learning while learning through individual and collective EEG; teacher characteristics and their perceptions of the success of EEG usage. The research has also captured the perceptions of the teachers about the Individual-collective EEG readiness of the students, the usefulness of the EEG tools, and EEG achievement of educational outcomes.

This research has made significant contributions to the area of the effectiveness of EEG usage in enhancing learning outcome achievement in primary education with specific reference to the Arab world, where very few studies have been carried out in this area. This research led to a recommendation that the usage of EEG extensively on all courses where it is applicable, in both the individual and collective modes, as it has a significant influence on student learning. As the collective mode was found to be more effective than individual EEG, it has been recommended that the teachers must explore various collective modes of learning and promote the same. It is recommended that the learning environment can be uniform for both genders and that it is unnecessary to pay special attention to gender. EEG's effectiveness and usefulness, as well as the achievement of educational outcomes was found to be positively perceived by the teachers based on educational qualifications, so the selection committee must be very sensitive towards the educational background of the teachers and select computer savvy teachers who are pro-EEG. The teacher's age, gender, designation, experience, and course taught should never be the criteria for his/her selection, provided that the other requirements, such as fitness, experience and qualifications are met fully, as per the revelations of this research. It was also revealed that the selection of the EEG games had a significant influence on EEG effectiveness, perceived usefulness, and the achievement of the educational outcomes, so the judicious selection of EEG should be undertaken in consultation with the teachers. The research has also found that the teachers tended to be more positively inclined towards the collective mode of EEG than the individual mode because of the social dimension attached to it, which would support the constructivist approach to learning. They were also of the opinion that learning is not restricted to the topic being studied but has several other aspects attached to it, including soft-skills, culture building, and lifelong learning.

## 1.2. Research Questions

Researchers (e.g., Nunes-Dore, 2001; Fengfeng Ke, 2008; Al-Mashaqbeh and Al Dweri, 2014) have argued that children learn better in a collaborative group rather than learning individually. When it comes to the learning of mathematics, one of the primary objectives in primary education is to master the basic operations: addition, subtraction, multiplication, and division (Abdullah et al., 2012). Students need to be able to memorize the multiplication tables and recall them, so that they can solve problems related to the multiplication of large numbers, or division, and in later stages apply them in algebra, fractions, geometry, and calculus. Those who fail to memorize their tables may fall behind those who do so the process of learning tables is generally tedious and boring, as a general observation, for many students but the proponents of EEG claim that this boredom is reduced and learning mathematics becomes quicker if tables learning is made more interesting through gaming (Pillay et al., 1999; Rieber et al., 1998 and Rosas et al., 2002; and Garris et al., 2002). Further, a group of researchers claim that collective learning through gaming is more beneficial in terms of enhancing learning (Rowe, 2001; Bragg, 2006; Dondlinger, 2007; Skoumpourdi and Kalavassis, 2007; Papargyris and Poulymenakou, 2009; and Al-Mashaqbeh and Al-Dweri, 2014). Even though there have been several comparative analyses of different methods and approaches to learning mathematics, few have provided empirical evidence for their conclusions. The EEGs are used in two modes in this research: individual mode, where a student interacts only with the electronic gadget; and the collective mode, where in addition to the interaction with the electronic gadget the students also interact with their classmates. This gives rise to the following research questions:

- RQ1 What is the effect of individual and collective EEG on the academic achievement of learners while studying mathematics in primary school?
- RQ2 What is the effect of individual and collective EEG on the permanency of learning while studying mathematics in primary school?
- RQ3 What is the differential effect produced by individual and collective EEG on the academic achievement of the learner while studying mathematics in primary school?

RQ4 What is the differential effect of individual and collective EEG on the permanency of academic achievement of the learner while studying mathematics in primary school?

RQ5 What is the effect of the gender of the student on the learning of mathematics using individual and collective EEG?

RQ6 What is the influence of the gender of the student on the permanency of learning mathematics using individual and collective EEG?

RQ7 What are the teachers' perspectives on individual and collective EEG-based learning while studying mathematics in primary school? Do these vary with the teacher characteristics?

Among the seven research questions, the first two are not true research questions, as no control group was used in this study, so any increase in achievement can only be attributed to the intervention with caution. Rather, research questions 1 and 2 represent the first stage in the data analysis prior to identifying whether the two EEG conditions (individual versus collective) had a differential effect.

## 1.3. Organization of Thesis

**Chapter 1** sets out the aims of the study and the detailed research questions. My thesis includes seven research questions which are related to the individual and collective games in Kuwait primary schools. This chapter also details how the thesis is organised.

**Chapter 2** provides a critical review of the literature on the role of technology in learning. The lacuna in present-day primary education in the form of traditional teaching has been highlighted. The need for an activity-oriented approach to a subject like mathematics has been discussed and computer or electronic games-based games with an activity focus have been analysed in terms of their advantages over conventional teaching. The concept of gaming, which is activity-oriented, has been critically analysed. The literature that links the academic performance of the students with EEG has been compared and contrasted, and also the two distinctly different views regarding the contribution of EEG towards enhancing learning have been analysed. The studies related to the influence of gender difference on cognitive gain in the context of EEG usage have been discussed. At the end of this chapter, EEG usage in the context of learning mathematics, which is the focus of this research, has been discussed in detail.

**Chapter 3** records the various aspects of student engagement (or engaged learning), starting from its origin and development and extending to its relevance to primary education. The characteristics and indicators of engaged learning have been discussed, since these are of relevance to this research. The framework of engaged learning has been analysed in the context of this research. As this research is focused on the impact of EEG on learning outcome achievement, the measurement issues related to engaged learning have been discussed in detail. The proponents of EEG-based learning have mainly attributed it to be promoting student engagement and hence this discussion is relevant as far as the quantification of the attainment of learning outcomes is concerned.

**Chapter 4** compares and contrasts individual and collective learning (ICL). The eight fundamental conceptual orientations of ICL have been discussed in terms of their specific relevance to this research. The theoretical perspectives of learning have been critically analysed as they form the basis of knowledge acquisition both in the individual and collection forms of learning. The contemporary literature on ICL in the context of gender difference have been analysed to provide lead to this research. As EEG usage is studied in the context of ICL, these discussions provide immense scope for building a conceptual model of EEG-based learning in this research.

**Chapter 5** presents an overview of the methods and tools employed in this research. This chapter records the reason why the mixed methods approach was necessary. The activities undertaken in the qualitative and quantitative research components have been listed. The purpose in selecting a completely randomized design for experimentation in order to test the hypothesis has been recorded. The sampling method used in this research has been explained. The methods used to analyse the data in the form of descriptive statistics and inferential statistics have been explained.

**Chapter 6** places on record the research methods and research questions. First of all, the aims of the study and the rationale are discussed, which acts as a prelude to the research questions.

Seven research questions are presented in this chapter, and these form the core of this research. The answers to these questions will constitute the contribution of this research to the body of knowledge on EEG-based learning. These research questions have led to the development of the research hypotheses for the quantitative analyses. The methods used for the testing of each of the hypotheses have been explained in this chapter. The sequential steps involved in the development of the questionnaire used for the primary data collection have been listed. The pilot test of the questionnaire and the procedure adopted for its validation are also explained in this chapter.

**Chapter 7** records the findings in light of the students' test results. These results are mainly quantitative in nature, but also include qualitative observations on the participation of the students during the individual and collective EEG usage which are narrated in this chapter. This chapter provides answers to the first six main research questions. The statistical tests conducted on each of the hypotheses and the results obtained are also presented.

**Chapter 8** records the findings based on the teachers' test results. This addresses research question seven. This chapter basically presents the results obtained from the analysis of the teachers' perspectives on EEG. First, the teachers' perceptions of the knowledge of the computer usage of the students, the parents' skills, and the selection of electronic games have been captured in this chapter. Second, the teachers' perceptions about the usefulness of the EEG tools have been captured. Third, the impact of EEG methods on learners' achievement has been captured.

**Chapter 9** presents the findings on the effect of teacher characteristics on learner achievement based on EEG usage. The quantitative analysis is presented, during which the overall influence of teacher characteristics as well as the influence of individual characteristics on individual-collective readiness for EEG, EEG usefulness, and EEG achievement of educational outcomes have been tested for statistical significance.

**Chapter 10** presents the findings through the qualitative research based on the questionnaire survey and the semi-structured interviews with the teachers. These findings are specific to the suggestions to improve the individual and collective modes of EEG-based learning, teachers' perceptions about the usefulness of EEG-based learning, and the contribution of EEG to the learning of mathematics. Some insightful experiences of the teachers in connection with EEG-based learning have been recorded in this chapter.

**Chapter 11** presents the discussions and recommendations based on this research. The findings made in this research through the empirical study have been corroborated by the work of contemporary researchers. The influence of EEG in its individual and collective modes, the influence of gender on EEG in its individual and collective modes, the differential influence of the individual and collective modes of learning on learning outcome achievement and the permanency of learning, and the influence of teacher characteristics on EEG effectiveness, as studied through the outcome of this research, have been discussed in comparison to the contemporary research. The results of the analysis have led to a set of recommendations to the Ministry of Education to improve the effectiveness of EEG-based learning, which are listed in this chapter.

**Chapter 12** presents the conclusions based on this research.

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# CHAPTER 2

# The Role of Technology in Learning

## 2.1. Introduction

This chapter highlights the role that technology plays in the present-day educational scenario. The discussions on how technology can act as an enabler within the process of learning, the use of educational electronic games as learning tools, the role played by educational games in the academic performance of students, the influence of electronic games on gender, and the usage of educational electronic games in mathematics learning are included in this chapter. A number of theoretical perspectives regarded as being particularly helpful are also discussed. The discussions are oriented towards the learning that takes place in primary education with the aid of technology.

## 2.2. Technology - An Enabler of the Learning Process

Steinkuehler (2010) defines learning as a process for creating knowledge and the life experience to use and apply it in real-life situations. The major criticism of the conventional mode of learning in schools is that it provides theoretical knowledge to some extent, but fails to do justice to the development of a number of skills required for successful career development and future learning, including problem-solving, decision-making and collaborative learning skills (Pruet, Ang & Farzin, 2014; McEwan, 2014 and Euler, 2011). The lacuna in the present system of learning in schools is adequate input for students regarding the generation or creation of knowledge and the application of the same. Attempts are being made continuously to use technology in learning to compensate for this lacuna. Technology has gained popularity as it has the ability to carry out various processes and offers tremendous potential to make these processes more effective. As learning is a process, technology has invaded this domain as an enabler.

The focus of this research is on the learning of mathematics. The National Council of Teachers of Mathematics (NCTM) in the USA has stated clearly that technology is an essential tool for learning mathematics and that all schools must ensure that technology for learning mathematics is made available to students (NCTM, 2008). It was also declared by the NCTM that it was the teachers' role to enable students to develop an interest in the use of technology in learning mathematics so that they may become more self-reliant and life-long learners. A similar model has been adopted in Kuwait, where the government wants schools to incorporate technology into the teaching-learning process and provides the necessary support to exploit technology in the process of learning.

Kloosterman and Gorman (1990) emphasized the need to focus on activities when teaching mathematics. According to them, 'activities' make students feel skilled in mathematics and confident about learning and, above all, it gives them a sense of ownership over their learning on completing the activity. It also makes them task-involved and motivated towards the subject. Activities can be physical or simulated through the use of technology. The rapid growth in computer technology in the recent past has made it very convenient to use technology as a tool to create simulation-based mathematics activities. These activities can include animation, colour, sound, and graphics, which can make them seize the attention of the students and keep them involved for a longer period. The learning process of mathematics can also be made more flexible and cater for different levels of difficulty, so that students can engage in the progressive development of their knowledge. Koc (2005) opines that computer technology offers a choice to introduce new mathematics content to the existing ones, and can be used as a strategy for motivating students and improving their learning. Bransford et al. (1999) claim that technology offers dual advantages as it enables students to learn better and teachers to teach better. In terms of the students, it can provide them with a series of activities to work with in the field of mathematics, or any other subject for that matter, and so make studying more enjoyable and interesting. The use of computer technology can improve communication skills, team building skills, problem-solving skills, and the students can explore different representations of mathematical ideas (NCTM, 2000). Teachers can build upon students' prior knowledge and skills, emphasize the connections among mathematical concepts, connect abstractions to real-world settings, and introduce more advanced ideas. Technology provides teachers with an opportunity to create a more dynamic learning environment. Technology can provide a platform for the creation of a large number of activities. Using computers to teach many maths topics, for example, shapes that can be introduced to students by using a computer environment that can generate multiple representations of a shape, can help students to generalize their conceptual image of that shape in any size or orientation (Damarin & Shelton, 1985). Van Eck (2006) claims that the use of technology in mathematics can promote learning and reduce the teaching time.

Zavaleta at al. (2005) claim that technology can improve the cognitive, social, and moral attitudes of the learners, and also make them more creative and independent. These claims are logical and rational, as the technology provides an opportunity for users to interact with each other. Cognitivism is the individual's construction of the representation of the world (Egenfeldt-Nielsen, 2006). It is strongly supported by the interaction of the learner with his acquaintances. These interactions with fellow learners will teach them how to elicit information from others and also share their knowledge with others. The students will also learn how to use the power of technology to solve their information-related problems. Along with these skills, the students will also learn how to socialize with friends and develop a positive attitude towards each other. Technology has always promoted the creativity of the students as it enables them to adopt alternative strategies to obtain results by providing several ways of exploring a problem. On using various forms of technology, mainly computer technology, the students develop a natural desire to explore alternatives (Kirriemuir & Mcfarlane, 2004). Technology provides several applications in the context of learning, but the focus of this research is limited to Educational Electronic Games.

According to Dori and Belcher (2005), the theoretical background of technology as an enabler to learning is based on social constructivism. As the social and cultural aspects of learning are important for knowledge generation, technology when used as an enabler has to incorporate these aspects (Hara & Kling, 2002). The meaning conveyed by the different aspects of learning with reference to the specific topic by the various features of technology and the process involved in the exercise are important (Wenger, 1998). As the social dimension becomes important in the technology used for teaching a topic, group discussions between the members of the group should form part of the technology-enabled learning process (Scott, 1998). Technology-based learning based on constructivist instruction, compared to the traditional teacher-oriented model, is considered to be more likely to result in the better comprehension of the topic (Shieh & Chang, 2011). Technology-based learning is considered to have context-rich content and provide students with an opportunity to observe, think, analyze, and elaborate on the underlying physical principles (Sokoloff & Thornton, 2004).

There have been many different technologies which have been integrated into the learning of mathematics. The virtual manipulative technology (VMT), which is freeware, was one of the earlier technologies developed in the 1990s, which links the students' previous knowledge and experiences to abstract concepts of mathematics in the context of primary schools (Suh, 2005). VMT is an interactive as well as visual mode of constructing knowledge in mathematics developed by the National Library of Virtual Manipulatives (NLVM). The purpose of VMT is mainly to provide a platform for students to use both physical and virtual manipulative objects. The main disadvantage of VMT is that it is a purely drill and practice type of exercise, which cannot be executed through direct instructions. Drickey (2000) observed the active participation by all of the students in the class when VMT was being used. A group of researchers worked on the suitability of VMT in the context of primary education mathematics learning and found that the students like VMT (Suh, 2005; Reimer & Moyer, 2005; and Smith, 2006).

Video games are also a valuable addition to the technologies employed in education (Kebritchi & Hynes, 2010). Several video games have been designed and developed by educational researchers and are used in primary education, covering almost every course. Hays (2010) opines that the fun, entertainment element of video games makes learning through them interesting.

Educational Digital Games (EDG) are another form of technology-enabled learning tool. Any technology-enabled game, for that matter, is a user-friendly, problem-based activity in which certain objectives must be accomplished using a set of rules and the player should be prepared to face challenges during its execution (Schell, 2008). Charles et al. (2009) found that the rewarding nature of EDG builds student engagement, and hypothesized that student achievement has a bearing on student engagement. NRC (2009) admits that EDG has the potential to strengthen student engagement while learning mathematics but that the linkage between EDG and student engagement is not yet fully understood. Researchers have found that EDG enhances student engagement because the teacher's explanation is replaced by direct action by the students; the games give a sense of ownership in terms of performing the task themselves so it motivates the students to take action; it can transfer a group of skills, such as problem-solving decision-making, communication, social skills etc., as the learning takes place; and provides a highly interactive, stimulating environment (Hirumi, 2010; and Kebritchi & Hynes, 2010). However, it should be noted that most of the claims that EDG improves student engagement are based on qualitative studies, and that there is little empirical evidence to support this view and also articles which oppose it.

## 2.3. Merits and Demerits of Technology-based Learning

The focus of this research is the influence of Educational Electronic Games (EEG) on learning outcome achievement. EEG is basically the one of the forms of technology in teaching. Unless there is a perceived benefit from using technology in the classroom, there is no point in using it. Several researchers have defined many different benefits associated with technology-based learning (TBL) (Ke, 2008; Dickey, 2010 & Yang et al., 2013). First of all, TBL can reach a diversified class of students across a range of subjects. The usage of TBL is independent of age, ethnicity, gender and many other demographic variables. TBL can teach students some vital aspects, such as setting goals, rehearsing, feedback on performance, and reinforcement, and also keep track of the progress they make in various subjects. TBL can measure individual differences among a group of students, standardize the learning procedures, induce the fun element of learning and stimulate students. It has the ability to hold the attention of the students for a very long time, as the learning can be very entertaining as well as exciting. TBL can introduce innovativeness into teaching. In the present scenario of learning, innovation has been given top priority because the educational institutes are competing with each other globally and it is necessary constantly to introduce innovation into the teaching-learning processes. TBL can support this very well due to the flexibility it has to accommodate new things. With TBL, the student has a very high level of interactivity during learning. TBL has a unique way of preparing students to engage in problem-solving, generating curiosity and accepting challenges which are the basic skills they need to possess in order to further their education. Early exposure to TBL will enable the students to overcome their technophobia which is observed in the older generation, due to which they have aversion to the use of technology. TBL may also help to overcome the problem of gender bias in teaching. TBL may enable students to develop the transferable IT skills which are required for their professional career. The ability to simulate situations through technology is a rare gift for students where they can visualize events, activities, processes, and happenings as close to the real-life situation as possible. TBL has the ability to improve the social skills of the students, as some activities may go very well when practised in groups. The students may develop a positive attitude towards learning due to the presence of technology and there could also be increased learning. TBL can enable students to learn a topic at different levels and upgrade themselves in a structured manner. As the assessment is made immediately, the students can know instantly their level of performance. TBL enables learning to go beyond the four walls of the classrooms, and 'flipped learning' aims to encourage this type of student interdependence.

At the same time, TBL may also have several disadvantages (Asplin et al., 2006; Fengfeng, 2008 & Kim and Chang, 2010). Researchers have opined that it may shift the focus of the students from learning a subject to learning about the idiosyncrasies of technology usage. The motivation and excitement created by TBL may be temporary and it may not be the natural ability of the individual. TBL may be unsuitable for teaching every topic on a course or even for teaching certain courses at all. It may reduce the teacher to student interaction, which may hamper the explicit knowledge transfer from the teacher to the student. As TBL keeps changing, the studies of its impact on the educational outcome achievement by the students may prove inconclusive. Schools must permanently face the challenge of upgrading the technology from time to time, and judging which application of TBL is best suited for teaching a topic may prove subjective and difficult.

## 2.4. The Technology Acceptance Model

EEG-based learning is a relatively new, technology-based learning tool. Whenever a new technology is introduced to provide a specialized service such as learning, it must be diffused across the market, which means that the market must absorb the technology wholeheartedly as it makes the process of learning simple and at the same time effective. EEG is basically a technology-based tool for enhancing learning. It needs to be diffused across the market in a systematic manner which should be studied, as this research is all about deploying technology in a teaching context. The most-widely accepted model which explains this process of diffusion is the Technology Acceptance Model (TAM). This was originally developed by Fishbein and Aijzen (1975) as a more generalized theory and later developed by Davis (1989) to identify the determinants which encourage users either to accept or reject a particular technology by integrating the technological aspects with the organizational behavior concepts. According to this model, while there are several determinants of the user acceptance of a technology, the two most important ones are perceived usefulness (PRU) and perceived ease of use (PRE). PRU refers to the improvements that can be expected in the performance of the job with the aid of the technology, while PRE refers to the perceived ease of using the new technology. This model has been very successfully used by researchers from diverse fields, including knowledge management, information systems, mobile learning, educational settings and healthcare settings (Huang et al., 2007; Liang et al., 2003, Chau and Hu, 2002).

Venkatesh and Davis (2000) added two further determinants to the TAM: Social influences (SIF) and cognitive instrumental processes (CIP). The former included subjective norm (SNM), voluntariness (VLT), image (IMG), and experience (EXP). Subjective norm refers to the influence of peers on whether an individual should perform in a particular way or not. In a typical classroom environment, this would be the student's perception about whether he/she should follow what others do or explore the newer options available in the EEG. It could also relate to a student's perception about what his/her teacher or classmates might think about them behaving in a particular way while using the EEG. Voluntariness refers to the mandatory and non-mandatory usage which influences intentions. Image refers to the status related to the technology with which the user associates. Experience refers to the changes which may occur based on the experience with the newer technology, say EEG. The cognitive instrumental processes include the learning outcome achievement relevance, output quality, and result demonstrability of EEG. So, these additional elements are supposed to influence the acceptance of technology.

The TAM was further modified by Venkatesh et al. (2012) to place greater emphasis on 'perceived ease of use'. They added the dimensions: computer self-efficacy (SFC), perception of external control (PEC), computer anxiety (CAX), and computer playfulness (CPF). SFC refers to the belief about the ability of an individual to perform a task via EEG. PEC refers to the perception of the individual about the institutional and technological integration in the context of the new technology, such as EEG. CAX refers to the fear factor associated with acclimatizing to the newer technology. So, the dynamics of these aspects has a role to play in the usability of EEG in the learning environment.

## 2.5. Educational Electronic Games (EEG)

EEG basically involves the integration of technology into the educational process in general, but strictly speaking EEGs are also a specific form of technology. The educational media are varied and can be used to support many different teaching approaches. Audio-visual techniques have been practised due to their perceived strengths in learning. On the other hand, different countries based on their culture and financial background, have adopted different teaching techniques, including the use of computer games.

Playing represents a vital part of a child's life, which he/she engages in every day. Playing, in a child's life, is considered one of the most important factors, affecting and forming the cognitive, motor and emotional nature of the child.

Primary schools have also paid the attention to the issue of using different playing tools and forms, considering the child's age as an essential learning parameter. It is recognised that play is not only a method of entertainment, but also an activity that has a deeper target linked to learning.

EEG is a gift to the younger generation in the current era and children are very well attuned to this interactive mode of entertainment. Having observed the involvement of children in electronic games, educators have attempted to combine electronic games with the curriculum so that children may learn through entertainment (Kirriemuir & McFarlane, 2003; Ang & Wang, 2006; and Harding et al., 2009).

Kandil and Badawy (2007) indicated that recent studies have discussed children's growth and development. The term “grow” was emphasized to show that using the abilities of children and their different senses are key issues in learning and development. The authors added that games are no longer considered as a form of entertainment only, for children to engage in during their leisure time, and not simply as a means to achieve physical growth, but they have become important tools that children use to enhance their mental development.

Al-Dhlawy and Al-Hamidy (2011) stated that the care that educators in schools and students' guardians devote to the social and emotional growth aspects appears to have a strong influence on students’ achievement. Psychologists call middle childhood the "playing stage", as children devote more time to play during this period.

Educational games are defined as: "a method that aims to increase students' understanding of theoretical concepts, through embodied practice, or through the use of computer software, in order to raise their attention to the subject, and increase their activity and motivation to learn and understand its content and reach their desired educational goals" (Flatah, 2008:28). This definition of educational games explicitly states that the games the learners play help them to understand the theoretical concepts, which is the quintessential requirement of an education system. Thus, the educational game has the ability to do the job of a teacher in a more entertaining and interesting manner for the learner. The second component of the definition claims that the educational game also an ability to ‘increase attention to the subject’. This is again a challenging task for a teacher to achieve during classroom teaching. The teacher may have to use many different techniques to attract the attention of the students, whereas educational games naturally attract students’ attention because of the animation, graphics and sound that are added to the content. The last component claims that the educational game also has the ability to ‘increase the activity and motivate to learn and understand the content and reach the educational goals’. One of the primary goals to be achieved in the educational system is to transform learners into ‘lifelong learners’. Educational games can achieve this purpose as they enhances learners' educational activity and motivate them to achieve their educational goals. The motivational component added to the process of learning will transform learners into lifelong learners.

Al-Hila (2007) indicated that there are different types of playing activity styles. They are all based on the interaction with the game that varies depending on the style of practice, whether it is individual or collective. When learners play educational game and learn individually, they interact with electronic gadgets on a one to one basis (usually a computer or a mobile) so their performance is assessed by them individually but, when they learn collectively, they interact with the gadget in a group and so can compare their relative performance. There are also electronic games where the individuals can play against each other in teams. There are many features of play, as follows (AL-Hila, 2007) (Figure 2.1).

- Fun and pleasure are considered a major aspect of play and a purpose achieved by the players through playing, which often leads to learning.
- Through play, we can exploit both the mental and kinetic energy of the player at the same time.
- Play is related to the internal self-motivation of the child, as it requires speed, agility, attention and an open mind.
- Play is a fundamental requirement for the child's knowledge and thinking growth, and meeting his/her development needs.
- Play is a fundamental requirement for exciting children's thinking, expanding the scope of their imagination, and building mental conceptions of things.

"Using playing in education in general and using its educational techniques in particular, is considered a part of developing and updating education, which ensures the preparation of the future human being to be able to adapt successfully with the successive changes resulting from the knowledge and information revolution and the continuous scientific and technical progress; and prepare him/her to face the problems of life with ease and convenience, considering the fertile environment provided by the educational games which help in the child's growth, evoke his motivation. Urge the children to interact actively with the educational material in a realistic atmosphere that is close to their sensory perceptions, and make them attracted to them, and seek to handle them in a funny interesting way to achieve certain goals" (Al-Harby, 2010:9).

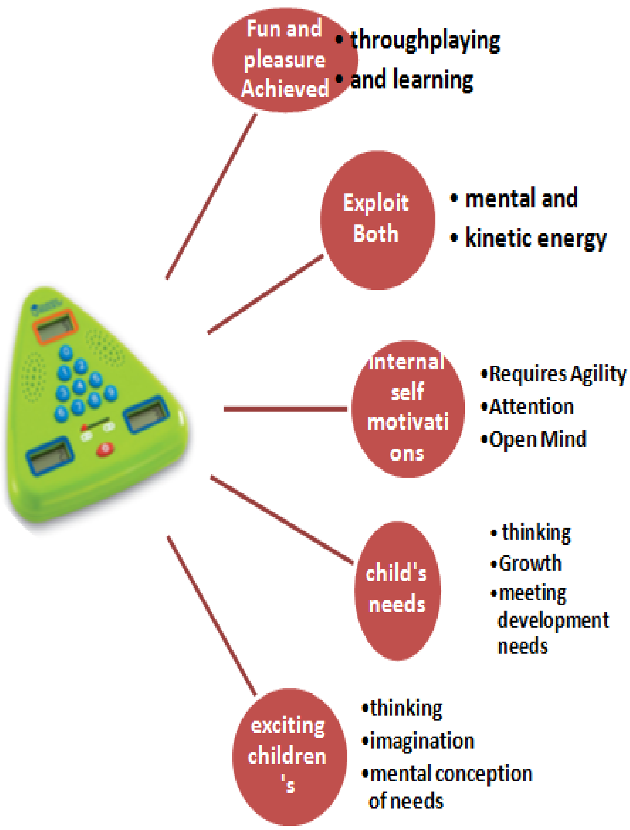


Figure 2.1: The various features of playing games (Source: Al-Hila, 2007)

Playing develops "the child's mental, physical capabilities and gives him opportunities to create positivism towards others, and towards educational outcomes, and educational activities and his growth" (Salama, 2006:20). Ebid (2007:15) indicated that "multiple levels of play vary, according to the levels of children development and that the forms and types of games are closely linked to stages of their growth". According to Affana (2002), Alhila (2005) and Alhowaidy (2006), educational games aim to contribute to the integrated development of the student's cognitive, psychological, and physical aspects. According to these authors, educational games develop personal problem-solving abilities, build self-confidence, develop a positive outlook, improve self-satisfaction, reveal natural abilities, develop self-expression, promote creative and innovative skills, and provide an opportunity for children to discover their feelings, attitudes and values. "The activity of educational games captures the feelings of the learners and leads to increasing attention and focus on the activity they exercise" (Alsalama & Saleh, 2008:30). The technical aspects of electronic games are developed on the basis of whether they are to be used by individual students or a group of students. When developed for an individual, these games capture individuals' feelings whereas, when developed for a group, they capture the group's behaviour and collective attitude. In both cases, they are oriented towards the increased attention of the users and focus on the activity to be accomplished.

"Electronic educational games (EEG) can be defined as a series of programmed activities which increase the motivation of the learner for the high degree of interactivity that they provide, and they are also characterized by pleasure, excitement, and provoking imagination in an educational framework that aims to creating an atmosphere of challenging the learner's thinking to reach the unusual solutions of the game's problem under the supervision of the teacher, and to reach the information included by the game" (Badawy, 2008:9). According to this definition, EEG may have an inbuilt motivational component as well as an element of interactivity but the teacher's intervention is unavoidable. However, it is limited only to facilitating learning and improving the level of information assimilation through the game. The feature to be noted is the ability of EEG to spark the imagination of the learner and challenge his/her thinking. These two aspects are very difficult to achieve by the teacher who adopts a conventional 'chalk and talk' method of teaching. The main difference between teaching in a group and EEG is related to individual attention. Teachers cannot pay individual attention to learners all the time, but each learner using EEG maintains individual control over the game and is completely involved until all of the information has been gained. The only intervention required of the teacher would be to test whether or not the educational objective has been accomplished. The definition given by Badawy appears to be complete in most respects; nevertheless, there is no mention of the individual and collective influence of EEG, which is the focal theme of this research which needs to be explored.

"Electronic educational games are considered the most popular and exciting interactive software, as the computer engages the students through software and encourages them to learn through playing, such as an interesting game that includes in its context a specific concept or a certain skill" (Afana, 2002:282). Afana focusses on the 'learn through play' concept of EEG. In general children enjoy playing games (Ang & Wang, 2006) and despise conventional classroom learning. They seldom feel bored while playing, unlike during classroom chalk and talk teaching. The teacher must create interest in learning, whereas they are genuinely interested in learning. So, the most important feature of the EEG is that it can put the learner into the 'playing mode'. As children have a natural tendency to play, they will explore the game and, in the process, acquire knowledge about a subject. Al-Far's definition, no doubt, has touched the very fabric of EEG, which is the play mode of learning, but fails to account for the epistemological aspects of EEG, such as how the game puts learners into the 'play mode', how the subject content is transformed into EEG, or how EEG can be made interesting to the student? This aspect needs to be further explored.

"Educational games depend on competition while achieving goals" (Mandor, 2007: 262). This definition put forth by Mandor successfully identifies a new dimension of EEG - 'competition', which was ignored by the earlier definitions. Children enjoy competing with each other in any activity for that matter. A positive spirit of competition can enhance the performance of learners. There could also be a negative effect of competition where, after losing to a better performer, may become depressed or lose interest in the game. This is where the teachers play a role in encouraging them to keep going. Usually, rewards of various forms can promote learners consistently to perform better. However, Mandor mainly considers collective EEG, whereby a group of learners participate in EEG and compete with each other. This does not rule out the possibility of learners competing with themselves; for instance, there are games in which learners can repeat exercises until they acquire a satisfactory level of performance by comparing their performance with their own earlier results. So, in that respect, competition can be with one's own self and Mandor's definition holds good. To some extent, motivating the students through competition may be possible during conventional teaching too. It could be through asking questions after covering a topic and acknowledging the achievement through the right answers given by the students. However, using electronic media, the competitive spirit can be enhanced further through rewards in the form of points and other benefits.

Boshnaq (2005) emphasizes the standards that should be maintained in educational games, which include: simplicity of design, as games with complex specifications limit the freedom of students to express themselves, as well as reduce excitement and stimulation. The multi-faceted tools and activities of educational games must be usable in different educational settings, be suitable for easy handling by different age groups, be robust, meet the required rules of society, and suit students' varied experiences. The emphasis of Boshnaq is on standards for EEG. Simplicity is the first aspect he expects the EEG to have as, unless it is simple and user-friendly, the children may lose interest in the games. Only when the games are simple to understand and can be used with ease can children become absorbed in them, as they have a very limited ability to deal with complex problems. As rightly mentioned, excitement and stimulation should be the part of the activity, as children love excitement and like to be stimulated often. Multi-faceted material which exposes students to diversified fields may not only make the game interesting, but also expose them to different subjects and promote the overall growth of students. Students who are diverse with respect to age, gender, background, intelligence, experience, etc., are unavoidable in a classroom and EEG must be able to accommodate these variances among students. It must be appealing to all types of students. Boshnaq also emphasizes the robustness of EEG and wants it to abide by the rules of society. The material should be designed to be tamper-proof and conform to the generally acceptable practices of society. This feature is of specific importance in a traditional environment like the Middle East. The rules are rigid and should conform to the religious practices prevailing in the country.

It is clear from the above discussion of the definitions of EEG that there is a varied explanation regarding the very concept. The emphasis of different researchers varies with respect to the components of EEG and the expectations as well as outcomes to be achieved through it. The unification of the definition is farsighted, as EEG as such is a multi-dimensional construct and the role and deliverable may even change with the advent of newer technologies. However, in the context of this research, the following operational definition combines those discussed earlier:

"EEG is a an educational technology that captures the feelings of the students and motivates them towards a subject and attempts to achieve a predefined educational objective by making the activity interesting, interactive and enjoyable".

A group of researchers opine that a game is a set of rule-guided, goal-directed activities that has the ability to kindle the competitive spirit among the players (Crookall et al., 1987 and Dempsey et al., 2002). A game is strategy-driven, involves chance or skill, and incorporates competition and/or risk-taking which make it interesting. Alexander and James (2005) add the features necessary for a quality game, claiming that a game allows multiple entry points the enable the participants to enter at their own level, promotes discussion, particularly describing and justifying thinking, and has an unpredictable outcome. When the gaming concept is applied to education in the context of learning, it becomes an educational game. According to Oldfield (1991), an educational game involves a challenge against a task or opponent(s), has a definite set of rules, keeps the player freely engaged, offers a definite number of solutions, has an ending or finishing point, and has subject specific learning goals. A well-designed educational game must promote more than mere concepts, knowledge and skills. It should encourage children to invent and test multiple strategies, communicate, negotiate rules and meanings, cooperate, and reason (Sarama and Clements, 2009). The educational games in which electronic technology is used as the enabler constitute EEG. Usually, children enjoy playing games because of their entertainment value and the thrill of achieving their goal through sustained effort. When these features of games are effectively used to accomplish the educational learning objectives using electronic means, they become EEG. In other words, EEG is an immersive, voluntary and enjoyable activity in which a challenging goal is pursued according to agreed rules using the computer and communication technology (Prinsky, 2001 and Kinzie & Joseph, 2008). The use of EEG is now a universal phenomenon (Jackson, 2004). Historically, EEG was used to learn specific scientific disciplines such as Science and Engineering and, of late, it is being used in primary and secondary education. These technologies have been used in the learning of different courses such as English (Lui & Chiu, 2010), Mathematics (Ke, 2008; Lowrie & Jorgensen, 2011; Chang, Wu, Weng, & Sung, 2012, Lin et al., 2013), Decision-science (Chang, Peng, & Chao, 2010), Natural science (Hwang, Wu, & Chen, 2012), Science (Meluso, Zheng, Spires, & Lester, 2012), Vocabulary learning (Frederick, 2010), Computer science (Papastergiou, 2009), Physics (Francis et al., 2009; Wambugu & Changeiywo, 2008), and many other courses in both primary and secondary education.

Even though the specific interest of this research is mathematics learning in primary education, the outcomes of the use of electronic gaming in other subjects would also help as the 'soft' aspects of learning such as the psychological and cognitive elements, which have a bearing on the ability to create interest in learning, influence the attitude, and vary the motivational state of the student. The capability of simulation-based EEG is that it involves a series of interconnected processes with multi-component systems and facilitates cultural empathy and creates new identities (Jackson, 2004). It can grab the attention of young minds and expose them to a highly dynamic environment, which is not only stimulating and entertaining, but also at the same time accomplishing the task of learning a particular subject. There are other benefits of EEG, such as eye-hand coordination, visual-spatial ability, a positive attitude, etc., (Egenfeldt-Nielsen, 2006). The main concept of EEG is that it teaches complex systems to learners through cause and effect relationships, which makes the learning process sequential and logical. Clearinghouse (2002) states that EEG exemplifies positive pedagogical practices, as it is active, social, and reflective.

According to Gee (2003), it is the ability of the game to create meaning in the multimodal space through embodied experiences to solve problems and reflect that makes EEG interesting as well as effective in achieving the outcomes. Papargyris and Poulymenakou (2009) claim that it is the 'persistence' that can be created by EEG that makes the difference and is critical for the social dimension. Euler (2011) states that EEG distinctly stands apart from traditional teaching as it has the ability to engage students through interactive learning, problem-solving, conflict resolution, experimentation and the laboratory environment.

Essential features in a game environment are authentic fantasy contexts, rules/goals, and challenges (Thornton & Cleveland, 1990 and Gredler, 1996). Research on EEG has proved that game features enhance dynamic cognitive processes and so promote meaningful learning (Pillay et al., 1999; Rieber et al., 1998 and Rosas et al., 2002; and Garris et al., 2002). The results of EEG studies prove that it is easy to use and allows learners to focus on activities (Zurita et al., 1999).

Several educational benefits of using EEG in teaching have been identified by researchers, including: exposing students to meaningful learning situations, building confidence and motivating them to study particular subjects, enhancing learning, building a self-concept, developing positive attitudes towards the subject, formalizing learning, providing an opportunity for collective learning, providing students with opportunities to self-assessment, providing flexibility in learning in terms of space and time, improving students' problem-solving skills, actively constructing concepts and skills in a social context, community building, relationship building among teachers and students, listening skills, taking turns, following directions, team building, group discussions, coordination building, action justification, reasoning skills, rationalizing skills, and giving/considering suggestions to/from others (Rowe, 2001; Bragg, 2006; Dondlinger, 2007; Skoumpourdi & Kalavassis, 2007; Papargyris & Poulymenakou, 2009; and Al-Mashaqbeh and Al-Dweri (2014). Thus, in addition to learning objectives, EEG has the potential to develop several skills among learners.

## 2.6. Academic Performance and Educational Electronic Games

In the modern, computer-driven world, the majority of children use electronic games in one form or another (DeBell and Chapman, 2004). Due to this, electronic games have attracted increasing attention in the past two decades, as attempts are being made to use them as a learning tool because they can be fun as well as effective for children (Oblinger, 2006).

There are distinctly two different streams of arguments with regard to the contribution of electronic gaming as an aid to enhancing learning and enabling children to develop a positive mental attitude towards learning. Some researchers agree that, by incorporating the proper principles, electronic games can be a very powerful tool for enhancing learning (Gee, 2005), that can influence the affective domain of learning and also foster children's positive mental attitude towards learning, language development skills, computer literacy, geography, history, mathematics as well as management and financial studies (Rosas et al., 2003; Ebner & Holzinger, 2007;  Ke & Grabowski, 2007; Ke, 2008; Dickey, 2010; Burguillo, 2010; Kim, S., & Chang, 2010; Yang et al., 2013). Research has shown that EEG promotes students' learning (Mayer & Moreno, 2002) and also enhances their social skills (Bosworth et al., 2002). Research studies have proved that EEG has a positive influence on student engagement and achievement (Bottino et al., 2007; Ke, 2008; Kebritchi et al., 2010; Echeverria et al., 2011 and van der Spek, 2011).

Kloosterman and Gorman (1990) have found that EEG make students feel skilled in the mathematics classroom and also more confident and motivated with regard to learning the subject. A study by Annetta et al. (2009) found that, in the 5$^{th}$ grade science class, electronic games showed positive performance. Oblinger (2006) found that electronic games can make classes enjoyable for students and also enable them to perform better. Lee at al. (2004), through their empirical study, proved that students who were trained in EEG could solve problems three times faster than those trained by traditional teaching methods. Laffey et al. (2003) compared traditional teaching with EEG-based teaching and found that, with the latter, students not only paid more attention but also achieved more when learning mathematics. Empirical research has found that EEG improves children's cognition and social processes (Kim at al., 2009 & Yien at al., 2011), while Roschelle et al. (2000) found that it developed the Higher Order Thinking Skills (HOTS: Analysis, Synthesis and Evaluation) among children. Al-Mashaqbeh and Al Khawaldeh (2009) compared traditional teaching with EEG and found that the latter produced better results, and Ke and Grabowski (2007) produced similar results with reference to Mathematics classes. In both of these studies, the electronic games mode of learning was compared with the traditional teaching methods. The literature supports the view that educational games are an effective means of improving students' attitudes towards mathematics, particularly in terms of attracting students' attention, improving their engagement (Malone, 1981; Rieber, 1996), increasing their motivation (Ernest, 1986; Kamii, 1996; Bragg, 2007) and engagement with mathematics (Squire, 2005; Barab et al., 2005; Young-

Loveridge, 2005), helping to build positive attitudes towards maths (Bragg, 2007), and increasing self-esteem (Ernest, 1986). Other researchers have directly proved that EEG has a significant influence on students' learning performance (Brom et al., 2011; Huang et al., 2010; Wang & Chen, 2010). Many researchers have found that EEG has the ability to improve learning skills, motivate students to learn, and enhance a group of skills (cognitive development, problem-solving, communication, collaboration, decision-making, self-reliance and a positive mental attitude (Prinsky, 2001, Mitchel and Savill-Smith, 2004, VanDeventer and White, 2002, and BECTA, 2001). Several researchers have also found that EEG has the ability to turn children into lifelong learners as it motivates them to learn (Crawford, 2002 and Norris, 2003). Combining the results of several studies, Ke (2008) identified that EEG has the potential to: improve student engagement, encourage active learning by doing, make complex subjects easily understandable, and promote collaborative learning. Academic performance has all these components because a student must only learn but also share his/her knowledge with the rest of the group.

So, it is evident that many benefits can be derived from EEG but, in direct contrast to this, another group of researchers question its role in promoting cognitive gains, academic achievement, and other benefits. According to Asplin et al. (2006),

*"Games in the teaching and learning of mathematics are often ill-defined and are used sometimes as a time-filler or reward with little attempt to qualify, in terms of mathematics learning, why they are being used?" (p. 47).*

Ke (2008) compared the traditional method of teaching mathematics with the electronic method of learning using a sample of over 400 $4^{th}$ and $5^{th}$ grade students and found no significant difference in student performance. Kim and Chang (2010) investigated the performance of a sample of 170,000 $4^{th}$ grade students using both traditional and EEG-based teaching. They considered the main effect as well the interaction effects of their study variables related to learning and the results showed that those students who used EEG displayed a lower level of achievement in mathematics learning compared to those taught using the traditional approaches. Fengfeng (2008) conducted a similar study and found that the students showed a positive attitude towards the use of EEG, but that there was no significant difference in performance. Vogel et al. (2006) found that there was no causal relationship between academic performance and EEG. A common doubt about the contribution of EEG is that there is no empirically-grounded framework for integrating it into the classroom. Squire (2003) opines that introducing EEG may lead to a series of new problems, as it contributes to learning and improved academic performance, including factors such as: it may not be appealing to every student, students may be distracted by game-playing which may detract from their achievement of their learning objectives and goals, and the students may be attracted more towards the game part than the learning that has to take place. Some researchers feel that, by using EEG, the focus may shift towards the learning of concepts, such as reasoning, creativity, decision-making and understanding the system, and that some games may even lose their link to the curriculum (Egenfeldt-Nielsen, 2005). Research has shown that students who use EEG were associated with poorer academic performance, more aggressive cognition and behaviour, and more negative teacher ratings compared to those who studied without the use of EEG (Anderson et al., 2007). Playing educational games has been negatively correlated with player well-being and adjustment (Grusser et al., 2007). The negative correlation here is justifiable as replacement of human touch through the electronic gadgets may make the students have problems with adjusting with people and it may adversely affect their well-being too.

An extensive literature review is in progress to establish the relationship between student achievement and EEG but the literature available does not successfully establish the desired empirical relationship (Dempsey et al., 1993; Emes, 1997; Kebritchi et al., 2010). Perrotta et al., (2013) conducted an extensive literature review to check the impact of computer, video, and electronic games on students' academic achievement. Where studies expressly sought to measure 'academic achievement', five calculated some degree of improvement, although a meta-analysis of these studies observed significant, but undefined, cognitive gains across studies, and utilising games versus the traditional teaching methods. However, four studies found no impact on academic achievement. It is clear through the earlier research studies that while some researchers claim a positive influence of EEG on student engagement some other researchers disagree to this point. Thus, there is adequate scope for more studies investigating on whether EEG usage improves academic achievement of the students or not.

## 2.7. Cognitive Theory of EEG

This theory is of relevance to the research under consideration for its holistic approach to learning. EEG basically combines words, pictures and animation; hence, the theory that is applicable to multimedia-based learning is also applicable to EEG. There are two prominent theories which are applicable to the context of EEG: 1. Information Delivery Theory, and 2. Cognitive Theory. These theories are relevant to this research because EEG provides information to the students in an interesting manner and as they participate in the game they gain information e.g. how to add or subtract. At the same time there are a whole lot of cognitive aspects attached to EEG, which makes the students to comprehend, think, analyse and interpret situations and participate in the game electronically. These aspects are explained in the following sections.

### 2.7.1. Information Delivery Theory

This theory deals with the principle of adding information to one's memory (Mayer, 1996). It is theorized that the electronic gadget is a system for delivering information to learners. The EEG designer plays a role in supplying information and the students will play a role in eliciting the information e.g., when an explanation is presented in words (such as a narration), the learner can store the information in his/her memory. A Class of pupils is a heterogeneous group of students with different backgrounds, experience, and cognitive skills. Some may have the ability to register words and numbers easily, some others may have the ability to recall a picture, and many others may capture an animation accurately. So, instead of presenting the information only in verbal form by the teachers if it is presented as a combination of words, numbers, tables, diagrams, pictures, sound, animation etc., all combined with an intention to disseminate a particular knowledge, it should be in a better form to facilitate learning. Thus, according to the proponents of EEG-based education, the information delivery theory subscribes to the view that EEG should result in better learning than single medium presentations.

### 2.7.2. Cognitive Theory

According to this theory, students mentally construct coherent knowledge representation (Mayer & Morino, 2002). The term 'cognition' according to Oxford Dictionary means the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses (Oxford Dictionaries, 2015). Cognitivism is the thesis that moral judgments state facts and so are either true or false (Mayer & Morino, 2002). The Cognitive theory is built on the assumption of cognitive science experts that the human mind processes visual/pictorial and auditory/verbal presentations via separate channels (Baddeley, 1998; Paivio, 1986). Each channel can handle only a few pieces of information at a given point in time (Sweller, 1999). According to this theory, learning takes place when the learner selects and organizes the information received into a coherent representation, finally integrating it with his/her existing knowledge (Mayer & Morino, 2002).

Figure 2.2 summarizes the cognitive theory of multimedia learning. Narration enters via the ears, so the learner selects certain words for further processing in the verbal channel, organizes these words into a cause-and effect chain, and integrates them with their visual material and prior knowledge.

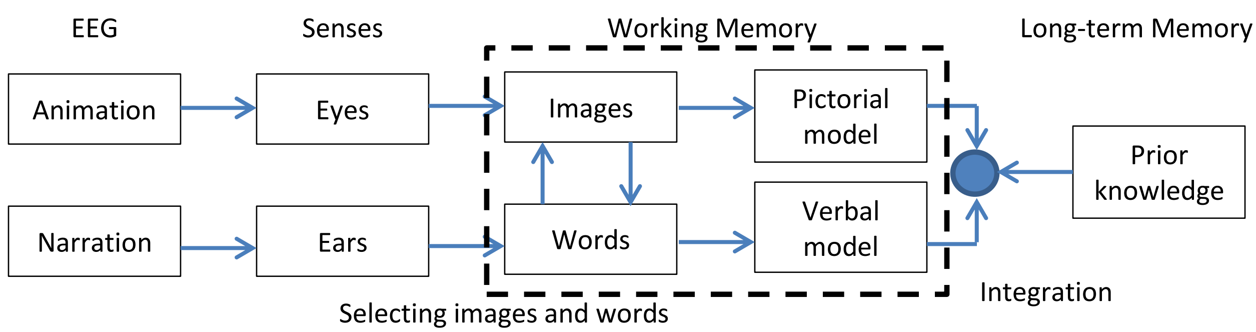


Figure 2.2: Cognitive Theory of EEG (Adapted from: Mayer & Morino, 2002)

Animation enters through the eyes and narration through the ears to reach the working memory of the brain which organizes the images into a cause-and-effect chain that it integrates with the verbal material and prior knowledge. According to this theory, the cognitive process of integration is most likely to occur when the learner has corresponding pictoral and verbal representations in his/her working memory at the same time. Instructional conditions that promote these processes are most likely to result in meaningful learning. Thus, according to this theory, EEG is more likely to lead to meaningful learning than single-medium presentations.

### 2.8. EEG in Mathematics Learning

Kloosterman and Gorman (1990) claim that EEG has the ability to motivate students towards mathematics learning and enable them to develop confidence, as it is more of a skill and activity-based approach. Repetition is the basic requirement for mastering mathematics skills. When undertaken on worksheets, it can prove boring to children, while the same task can be achieved through EEG in a creative and interesting manner (Baroody, 1989; Kamii, 1996 and Alexander & James, 2005). Bransford et al. (1999) found that technology can build upon the students' prior knowledge of mathematics, enables a connection between known mathematical concepts and also links the abstract to the real world settings. As EEG is governed by a set of rules, it enables learner to estimate, predict, and plan (Barta & Schaelling, 1998).

Several researchers have proved that mathematics learning effectiveness is enhanced through EEG (Swan & Marshall, 2009; Chang et al., 2012 and Lowire, 2011). The use of games builds on informal mathematics skills and assists in solving problems by promoting risk-taking and questioning as a means of constructing meaning (Baroody, 1989 and Braag, 2006). Skoumpourdi and Kalavassis (2007) found that games reinforce current knowledge and make connections within and across mathematics. By playing games, children can practise mental computations without the drudgery of making endless calculations in notebooks and so develop their mathematical understanding (Asplin et al., 2006). Games can serve as resources for estimating, approximating, simplifying complex problems, breaking down larger problems into simple workable parts, and enhancing children's pattern-seeking ability (Oldfield, 1991). Ramani and Siegler (2008) observed that, when children from low socioeconomic groups are allowed to play games for as short a period as 15 to 20 minutes, their mathematical skills significantly improved. According to Al-Mashaqbeh and Al-Dweri (2014), it is technology which has taken the driver's seat in modern mathematics learning because it has the ability to teach mathematics in a variety of ways. Koc (2005) takes the view that EEG has its own methods for introducing new lessons in mathematics which makes the learning process more interesting.

According to Al-Mashaqbeh and Al-Dweri (2014), EEG has the capability not only to provide a good learning environment but also to create newer tools which create opportunities to enhance the mathematics learning environment. Damari and Shelton (1985) and NCTM (2000), claim that EEG has the ability to enhance problem-solving and communication-skills, as well as equip students with different ways to present mathematical ideas. According to Zavaleta et al. (2005), it enables students to use mathematics in creative problem-solving situations.

Speaking in terms of the teachers of mathematics, EEG promotes learning and reduces the teachers' time spent teaching, particularly the newer theories and principles (Van Eck, 2006). It helps teachers to a great deal in building the personality of their students as it improves their cognitive, social and moral attitudes (Al-Mashaqbeh. & Al-Dweri, 2014). According to Kirriemuir and Mcfarlane (2004), EEG reduces the burden on teachers considerably, as it teaches them the essential skills required in the future, including strategic planning, communication, negotiation, and data-handling. Gough (1999) argues that it can be a very good supplement to classroom teaching and, as it reiterates the lessons taught by the teacher in different ways, the teacher need not repeat what is taught in class. One of the greatest advantages of EEG is that it encourages a competitive spirit, targets academic objectives, provides ample scope for improvement, and permits students to track their progress (Al-Mashaqbeh. & Al-Dweri, 2014). Dondlinger (2007) suggests that EEG should contain elements such as narrative contexts, rules, goals, rewards, interactivity and the procedures required to assess the students' progress. Akpinar (2005) suggests that it should not only create an interest in learning but also motivate students towards the subject which is being learnt. Roach (2003) suggests that EEG should incorporate the cultural component into its philosophy of learning so that students will be sensitive to these issues and learn to work in a multi-cultural environment. The real beauty of EEG is that the learner will be unable to differentiate between the gaming component and the learning component, as these are inseparably intertwined.

Researchers have also observed that EEG can improve assessment quality. Swan and Marshall (2009) found that EEG can provide teachers with an opportunity to make informal assessments of the strengths and weaknesses of students. Simply by observing and noting down the questions asked, the suggestions given, and the reasoning employed by the students, judgements can be made about their understanding of the subject and the process adopted for learning mathematics. Ugurel and Morali (2010) found that mathematical ideas, skills and the processes employed by the students can be easily understood by their teachers, and that can help them in their assessment.

There are many educational benefits associated with using computer games in teaching, as it can provide meaningful learning situations, support students to build a positive attitude towards mathematics, provide different learning opportunities for students, motivate students to learn, increase learning by adding more formal activities, create more interaction between students, give students opportunities for self-assessment, and improve students' problem-solving skills. It promotes interactive learning tasks and allows students to operate at different levels, thus enabling them to work independently as well (Davies, 1995). Ang and Wang (2006) attribute the enhanced performance in learning through an engaged learning strategy to the curiosity, student-centric approach, and individual-collective interaction. According to them, the students' natural curiosity to learn about the new environment to which they are subjected motivates them to engage in these activities. They were curious about how they would interact with the collective memory and accomplish the task assigned to them with a competitive spirit and always be in a situation of moving from the known to the unknown which they thoroughly enjoyed. The beauty of engaged learning is that learners, instead of being passive information receivers, transform themselves into active knowledge creators of the individual as well as the collective memory (Ang and Wang, 2006). The argument of many researchers about EEG and its role in engaged learning is that it promotes 'constructivist learning' and promotes the creation of knowledge for the self and the collective memory of the team. In our present information- and knowledge-driven world, there is a need for the present and future generations to interact with the collective knowledge and wisdom, in addition to individualized learning, so that the co-creation of knowledge takes place and EEG seems to have a significant role to play in this domain (Hirumi, 2002; Okan, 2003; Liaw, 2004 and Dickey, 2005).

According to some researchers, teaching mathematics using EEG is more of a behaviourist approach to learning (Good & Brophy, 1990; Lieberman, 2001 and Egenfeldt-Nielsen, 2006). In terms of motivation, it falls into the category of extrinsic rather than intrinsic motivation, as the focus is more on the gadget but, once learners are motivated towards the subject, as it is made easy and interesting, they may become life-long learners and become intrinsically motivated. Bragg (2003) claims that it is the enjoyment element of EEG that makes students intrinsically motivated. The behaviourist approach to learning originated basically from Albert Bandura's social learning theory (Egenfeldt-Nielsen, 2006). When a student learns a subject through EEG, he/she will become part of a group which interacts with each other and learning takes place in a social set-up rather than in isolation. It is the behaviourist approach to learning that makes EEG more enjoyable for students and to some extent fills the gap between education and entertainment (Egenfeldt-Nielsen, 2006). The entertainment value of EEG is purely a function of the technology, graphics, colour, animation, sound and other similar characteristics of the game. Many researchers feel that the behaviourist approach to learning has limited use, as the electronic gadget that is used to learn mathematics can only act as a facilitator to learning and extrinsically motivate the learner; however, it is this intrinsic motivation that enables a learner to gain proficiency in mathematical skills (Brody, 1993; Leyland, 1996 and Buckingham & Scanlon, 2002). The critics of EEG opine that, at a younger age, the entertainment elements may be of some use, as they act as facilitators of learning; however, at a later stage, learners need to be intrinsically motivated towards the subject to gain mastery over the topic. EEG cannot give a deeper insight into an area but it can focus on training through a set of mechanical operations in an interesting way. This may provide an ontological perspective but fail to do justice to the epistemological issues. Ontological knowledge may only answer 'what' type of questions e.g. what is 2+2? But 'how' 2+2 becomes four is not answered by EEG in its true sense. The training through EEG is process-driven and hence gives an ontological approach. This may turn out to be a very effective mode of teaching in answering questions close to the information received, but when it comes to higher order thinking skills, the results may not be very convincing. The teacher will be a role model for most students during their studies in schools and colleges. It is the interactions with teachers that make them develop confidence, form a positive attitude, develop leadership skills, and become a responsible, contributing citizen. So, a group of researchers express their concern about the limited teacher interaction with the students while using EEG, which is vital for the overall development of a student but missing to a great extent (Healy, 1999; Schank, 1999; Jonassen, 2001; Gee et al., 2004). However, the optimum mix of human contact and technology is always a challenge.

The subordination of learning to play experience itself is not an acceptable philosophy to many researchers, according to whom the goal of education is to promote student learning which should be the focus (Fabricatore, 2000 and Facer et al., 2003). Many researchers have noted that the player will not spend time on learning experience but rather get carried away by the gaming experience (Brody, 1993; Vandeventer, 1997; Fabricatore, 2000 and Facer et al., 2003). Despite all this criticism, EEG is still becoming popular as it helps children to learn in an interesting manner. According to its proponents, the goal of learning through gaming is to promote engaged learning and they claim that EEG may not be necessary for those students who are naturally attracted to the mastery of the laws and principles of mathematics, but very useful for slow learners and relatively less motivated students towards studying in general and mathematics in particular.

Some researchers oppose the behaviourist and extrinsic motivation approach of EEG and claim that it even supports the cognitive approach to learning. The cognitive approach places the learner at the centre of attention and the learning is through intrinsic motivation. The cognitivist approach is critical of the narrow focus of behaviourist approach in which there is a limited focus on the relationship between the stimuli and response. According to cognitivist theory, there are cognitive structures underlying the stimuli (perception) and response. People form the schemata representing what they have learnt. These schemata are formed based on the individual's cognitive capabilities. It is based on the individual's ability to perceive and process the information received. So, the intrinsic motivation of the learner becomes very important in building the schemata based on experience (Good & Brophy, 1990). When learners participate in the EEG, their schemata are being challenged by the game and its experience. The EEG presents the material in many different ways which can restructure these schemata and the learning takes place depending upon the learning limitation and cognitive abilities of the learner. EEG contains elements of discovery, inquiry, puzzles, problem-solving and communication, all of which are linked in many different ways and presented to form meaningful experiences. The learner who participates will start building his/her own mental models and structures through engaging in an active dialogue with the game. So, the supporters of the cognitive theory approach to EEG consider that learning through gaming is an experience in which learning and gaming are integrated in a meaningful manner. Egenfeldt-Nielsen (2006) gives the example of the research-based mathematics game *Super-Tangrams* in which geometric shapes have to be manipulated by the students. The learner needs to fit the different shapes into a given outline and the game becomes progressively more difficult and the process makes the learner curious and uses various approaches to tackle the problem and become self-motivated (intrinsic motivation), so learning and the process are so integrated that they support the cognitivist approach to learning.

The teachers' role in the EEG-based teaching of mathematics is limited to acting as a facilitator of the learning process, as mentioned before. This is a crucial role, as they have the responsibility for introducing the technology to the students and, if they do not discharge the required duties, this may hinder their progress or even make the whole process of learning go to waste. Honey et al. (2000) reported that teachers' professional development is one of the six factors that affect technology intervention in learning. Light (1997) argued that the failure of technology in EEG was partly because the teachers did not receive adequate training on how to use the technology nor how to use it properly to achieve the learning objectives. Standen et al. (2001) cite examples where EEG-based learning has been ineffective without adequate support and training for the staff, even when availability and accessibility issues were resolved. The class management skills which are demanded when EEG is used will be totally different from those adopted in the traditional classroom.

According to Holton et al. (2001), EEG in mathematics may have features such as: a solution-centered activity with the solver in charge of the process which uses the solver's current knowledge, develops links between the solver's current schemata while play is occurring, reinforces current knowledge through the links developed, assists future problem-solving mathematical activity, and where behaviour occurs irrespective of age.

## 2.9. Conclusions

This chapter has discussed the contemporary literature on EEG. Researchers have found that, while teaching may provide the required theoretical knowledge, the technology usage can equip the students with additional skills such as problem-solving and decision-making. The usage of technology is mainly in the form of educational electronic games and these have been used in almost every course in primary and secondary education. The interesting part of this research stream lies in the outcome which is diametrically opposed in terms of the contribution that educational games make to the enhancement of learning performance. While one group of researchers claims that EEG enhances learning performance, the other group disagrees with it. Even though the results vary in terms of the courses taught, the generalization of the outcome has not been fully possible by researchers in this field. The research on EEG performance in terms of gender is also inconclusive. As this research was focused on EEG usage in learning mathematics, several studies specific to this course were undertaken. Again, it has been found that there was no common consensus on whether EEG enhanced the learning of mathematics or not. Thus, there is immense scope for undertaking an empirical investigation of the influence of learning through EEG, particularly in the context of Kuwait, as most of the earlier studies were undertaken in Western countries.

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# CHAPTER 3

# Student Engagement

## 3.1. Introduction

In this chapter, the theories of student engagement have been discussed. The contemporary literature available on EEG-based student engagement has been compared and contrasted. The framework of EL has been discussed, as it defines the boundaries of this research. The main issue regarding student engagement has been the measurement of the extent to which this occurs when a particular mode of teaching-learning is adopted. Thus, the views of various researchers on the measurement of student engagement and the specific dimensions and variables for measuring student engagement have been discussed in this chapter. The defining of these variables has enabled the development of the measurement metric used in this research for the collection of primary data.

## 3.2. Student Engagement

Student engagement and engaged learning (EL) have been used interchangeably in the research literature and are considered to be a quintessential aspect of the teaching-learning process. Bodovski and Farkas (2007) claim that student engagement has the highest impact on the learning of mathematics. Newmann (1992) has observed that the important issue was not the students' achievement in mathematics, but the students' disengagement from mathematics that was causing the problem. Many researchers have attributed the disengagement of students from mathematics learning to the 'activities' which they are subjected to and not directly to the students' lack of motivation or disinterest (e.g. Childs et al., 2006). This implies that it is the activity to which they are subjected makes learning interesting or not. Suh (2005) found that high quality mathematics learning is possible only through implementing a meaningful set of activities which are very well designed which makes learning interesting, stimulating, entertaining and challenging. This makes it imperative to examine the student engagement aspects more closely and investigate those that enhance students' learning of mathematics.

Student engagement is the dynamics of time spent by the student, the effort applied by the student, and the learning environment that can enrich the student experience and enhance the knowledge and skills development of students, thereby leading to better academic achievement (Trowler, 2010). While keeping the students engaged for a given duration of time is part of the challenge, encouraging them to learn new concepts and develop their knowledge base is another aspect. EL has emerged from the theories of ‘learning by doing’, ‘inquiry based learning’ and ‘constructivism’, all of which theories support the concept of student-centric learning, whereby the ownership of learning belongs to the student and a social perspective is attributed to learning whereby students learn problem-solving through asking the right questions and engaging in appropriate interaction with their acquaintances (Inman, 2001; Keiser et al., 2014; Soma & Reynold, 2014; and Herman & Pinard, 2015). EL plays a significant role in developing the knowledge of students and turning them into lifelong learners. This concept was originally proposed by Dewey in the early 1930s in the form of inquiry leading to learning (Ang & Wang, 2006). Engagement in the context of learning refers to the activation of cognitive, affective, and motivational strategies adopted for acquiring knowledge (Bangert-Drowns & Pyke, 2001). EL is a philosophy of learning which combines several theories of learning, such as constructivism, situated learning, collaborative learning, active learning, and cognitive apprenticeship (Leonard and David, 2002).

Research studies have focused on the characteristics and features of EL to study its impact on student development. EL is characterized by the following (Jones et al., 1994):

- Excitement and pleasure to learn.
- Challenging tasks which are usually multidisciplinary.
- Performance-based assessment which is generative.
- Equitable standards of evaluation.
- Interactive and generative instructions.
- The context is knowledge building on a specific topic.
- The collaborative mode of learning is encouraged.
- Conducted over a heterogeneous group in terms of background, intelligence level, gender, etc.,
- Flexibility regarding the speed of learning.

- Teacher is a facilitator of learning.
- Students are explorers and teachers are co-learners.
- Students are considered as cognitive apprentices.
- Teachers and students co-produce knowledge.

EEG, which is the focal point of this research, has the ability to combine the above characteristics to a considerable extent. Another major area of research and debate is the indicators of EL. Research is in progress on the identification of the indicators which actually guide EL and ensure that the objectives are achieved. In the early 1990s, it was Jones et al. (1994) who identified the clear indicators of EL, which include:

1. **The Vision** - This defines what exactly EL is looking for on a long term perspective. The students are held responsible for their own learning. They need to set their individual objectives and evaluate their achievement. The students have to enjoy the process of learning and the exercise should make them life-long learners. The process of learning should be generative and each task's accomplishment should lead towards the next level of achievement. The students need strategically to plan for the entire process and ensure that each task is accomplished in a creative manner. EL is basically collaborative in nature so the students need to learn how to interact with their peer group and develop soft skills.
2. **The Tasks** – The tasks should be multidisciplinary, challenging and relevant to the topic being studied. The tasks are complex in nature and demand a certain amount of generative knowledge. The accomplishment of tasks demands the ability of students to interact with their teachers, peer group, and members of society. Problem-based learning may be the philosophy behind the accomplishment of the tasks.
3. **The Assessment** – Assessment is carried out to understand what the students know and what they can do. This can involve an authentic task accomplishment by the students, the completion of a project, seeking solutions to a specific problem, etc. It is followed by an observation of the results produced by the students, interviewing them to evaluate their knowledge acquisition through the task and examining their presentation and reports along with the artefacts, if any. The assessment in EL is purely performance-based as well as

generative in nature. It is important that the assessment has a close connection to the curriculum. Assessment should measure the level of competency gained by the student regarding the particular course being studied.

4. **Mode of Delivery** – This includes the instructional models and strategies adopted in EL. Researchers have opined that the most powerful model of instruction for EL is interactive (Jones et al., 1994 and Sloan, 2008). The fundamental concept of EL is to enable the students to construct knowledge and build it generatively. The interactive mode is used to enable the students to learn from each other. The mode of delivery is designed to 'co-create' knowledge. The strategies used in EL may include individual and group learning and summarizing, exploring multiple perspectives, brainstorming, etc.
5. **Learning Context** – The learning context of EL is a knowledge-building learning community. The community should be able to create knowledge as well as share it so that the process of knowledge generation is collaborative in nature. They key is to build the strengths of each member so that the team develops the required level of knowledge, skill and competency. The members of the community encourage increasing interaction through questions related to the problem being tackled so that one idea generates another and the collective knowledge of the group is enhanced.
6. **Grouping** – The grouping for EL is critical for its success as too many people would be a crowd and too small a number may be inadequate for problem-solving. While there is no hard and fast rule on the exact number, three to four would be ideal in most cases, as the learning opportunities will be maximized due to the close interaction between the members of the group. The group size also depends upon the instructions to be given by the teachers and, in such cases, the group's formation will be decided based on the strategy adopted by the teacher to pass on the instructions. Certain features, such as the heterogeneity of the group, will be an important aspect to consider in group formation and variations in terms of age, gender, background, culture, socioeconomic background etc., will be important as different perspectives can be obtained during the process of knowledge generation.

7. **Role of the Teacher** – The teacher's role shifts from a mere information giver to a facilitator for knowledge generation. The teacher also becomes a guide and co-learner during the process as he/she studies how the process of learning progresses and which technique will be more effective. The main role of the teacher in EL would be to provide an ambiance which is congenial to learning. The teacher may also play the role of a mediator and act as a coach during the process of EL.
8. **Role of the Student** – Exploration is the key role to be played by the student. Students need to interact with the physical world and relate their knowledge to it. In addition, they also have to interact with each other and exchange ideas so that newer knowledge is created in order to solve the problem at hand, develop an artefact or even seek an explanation of a phenomenon which is being studied. The student also has to encourage his/her peer group and motivate everyone in the group to contribute to the achievement of a common goal.

Researchers have expressed the view that learning can never take place without student engagement with the process of learning, particularly for subjects such as mathematics (Kong et al., 2003; Bodovski & Farkas, 2007 and Charles et al., 2009). At the same time, researchers have also found that students who are not engaged actively demonstrate post-performance in subjects with particular reference to mathematics (Fredricks et al., 2004 and NSF, 2004). Thus, the effectiveness of any tool used in the dissemination of knowledge or to assist the teaching-learning process has to be tested for its contribution to student engagement. Nevertheless, the work on student engagement has not been to the extent desired, particularly in terms of EEG. A deeper review of the literature has indicated that student engagement contains basic components which act together to produce a holistic form of student engagement.

Among the components of student engagement, the behavioural component plays a significant role. There are several behavioural components to engagement which include: positive and negative behaviour (Fredricks et al., 2004), the presence or lack of concentration (Finn, 1993), and involvement or isolation (Annetta et al., 2009). Researchers have found that without the behavioural component, the definition of student engagement will remain incomplete

(Appleton et al., 2008). Researchers have also attributed the behavioural component of student engagement to the involvement of the students in extracurricular and co-curricular activities with a proactive attitude towards learning from different sources (Fredricks et al., 2004). The behavioural component of student engagement can be identified by the teachers from whether or not the students take a keen interest in their studies, involve other students and interact with their teachers. In the context of this research, the behavioural aspects of student engagement are observed by the researcher during the individual collective EEG usage and through semi-structured interviews with the teachers.

Cognitive engagement is a component of student engagement which refers to the knowledge assimilated by the student, which involves the ability of students to know, apply, comprehend, analyse, synthesize, and evaluate knowledge. The students demonstrate their cognitive engagement through verbalizing, reasoning, questioning, justifying, planning, monitoring, inferring, concluding, creating, designing and evaluating (Annetta et al., 2009 and Hoffman & Nadelson, 2010).

Researchers have also observed that the behavioural and cognitive components of student engagement are not independently causing the student engagement but may overlap at times (Fredricks et al., 2004). This is because cognitive engagement is not always possible unless it is supported well by the behavioural intentions of the students. It is only when students behave in a particular way with their peer students they can develop knowledge and hence a positive attitude is generated through a particular behaviour which will be responsible for developing their cognitive capabilities. Researchers have also opined that cognitive engagement could lead to learning (Fredricks et al., 2004) and the behavioural engagement could lead to observable actions which could enhance performance in terms of learning (Jimerson et al., 2003).

The cognitive aspects of student engagement have been measured by researchers based on observable data, such as their performance in tests (Annetta, Minogue, et al., 2009 and Fredricks et al. 2004), but many researchers argue that the methods used to test cognitive engagement may not be the most appropriate, e.g., if the test scores obtained by the students become the reference, the very questions asked in the test are objectionable in the sense that they may not be the only measures (Fredricks et al., 2004 and Hoffman & Nadelson, 2010). Sometimes, the test scores may only represent the ability of the students to memorize a formula and reproduce it or remember how to apply it in a given problem situation but the real test of cognitive ability is when the students develop the knowledge and skills to apply the formula in many different situations. So, there must be alternative methods for testing the cognitive ability of students. In the context of this research, cognitive engagement has been measured by the test scores on a pre and post-test basis as it is one of the best and most widely-practised methods used by many researchers.

There is also the emotional engagement of the student which is the third component of student engagement (Fredricks et al., 2004 and Annetta, Minogue, et al., 2009), which can produce happiness, interest, zeal and enthusiasm or unhappiness, disinterest, and a lack of enthusiasm among students with regard to learning. A good measure of a student's emotional engagement would be if he/she loses track of time when involved deeply in learning. Emotional engagement is different from behavioural engagement in the sense that the former is based on feelings and the latter is based on the conduct of the student (Skinner & Belmont, 1993; Fredricks et al., 2004 and Annetta, Minogue, et al., 2009).

Emotional engagement is measured by researchers through the response of the students to a series of questions (Fredricks et al., 2004). While the measurement of behavioural and cognitive engagement is well-defined, the measurement of emotional engagement is still debated by researchers, as it is claimed that the instruments lack differentiated questions with specific reference to the tasks the students need to perform while learning a subject (Fredricks et al., 2004). In the context of this research, emotional engagement is beyond the scope of this research; however, some aspects have been studied in the qualitative component of the research.

Thus, it is clear though the literature review of the components of student engagement that behavioural, cognitive, and emotional engagement are not completely independent of each other and may overlap. So, the measurement of these three components individually is complex due to the multi-dimensional nature of the variable. However, the scope of this research is focused on the behavioural and cognitive components of student engagement and hence the measurement issues are less complex.

## 3.3. The Frameworks of EL

### 3.3.1. Hung's Model of EL

Hung et al. (2006) designed the framework of EL which depicts the key components involved with the learning (figure 3.1).

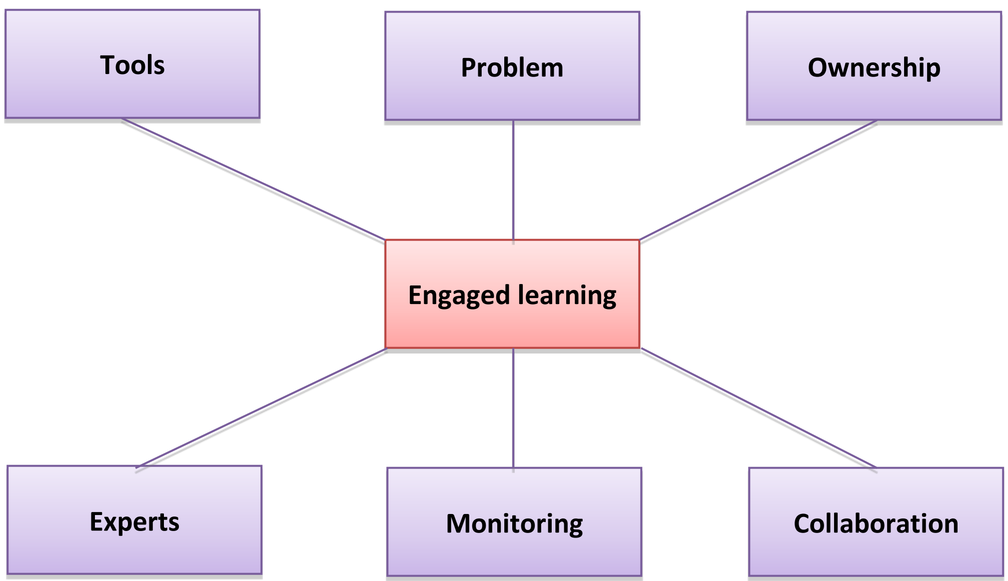


Figure 3.1: Framework of Engaged learning (Source: Hung et al., (2006))

**Problem**: The model specifies that the problem must be ill-structured, but closely connected to the syllabus. Students, while learning, should restore the structure and create the required knowledge, as prescribed by the syllabus. The compilation of the problem should be through a series of interactions among the teachers with a multidisciplinary component so that the students can link the various courses and topics that they are studying during the process of problem-solving. This approach will compel the students to apply their knowledge gained from various courses as well as the necessary skills to tackle the problem in a collaborative manner. The teachers should act as facilitators, guides, coaches and experts who provide some basic input so that the students can obtain a clear direction of the problem-solving process particularly in linking the various topics and courses.

**Ownership**: The students should shift into the student-centric learning mode and take the complete ownership in solving the problem. They have to make the best of the facilities in the learning environment and identify their own means of generating the newer knowledge that is required. The sense of ownership in problem-solving makes the knowledge generation interesting and also gives them a sense of responsibility. They will learn how to divide the problems into smaller individual parts and go more deeply into the concepts as well as reassemble them to get a bigger picture of the whole issue being resolved through their collaborative effort. They learn the process of investigation, inquiry, decision-making, experimentation, reflection, etc., all by doing, and hence will be relatively permanent. Every student will get an opportunity to be involved in the process of exchanging ideas and the collective responsibility makes the ownership stronger as well as more enjoyable.

**Collaboration**: Collaboration with peers is an on-going process in the professional life of an individual which has to be inculcated in early childhood. EL provides a perfect platform this. Students can divide the problem into specific tasks and then into sub-tasks and identify the strengths of the members of the group and distribute the tasks which individuals wish to accept. This provides an opportunity for students to work in the areas of their choice and present it to the group and, at the same time, allows them to compare their work with that of the others. Individual responsibility and accountability will also be demonstrated during the process of EL.

**Monitoring:** Students will learn how to monitor the process holistically. The process is in focus during the monitoring and not the product or the problem on which they are working. They will learn to use more than one form of evaluation technique to ensure that the process is on track. The students will also learn to make the monitoring process self-regulatory so that they will be in a position to track their progress and so fit into the time frame. As the teacher in the setting of EL acts only as a facilitator to learning, the onus is more on the students to monitor the process of problem-solving.

**Experts**: Experts are the ones who have the competence in the problem that has to be tackled in general in the context of EL. The present case is a primary school setting and hence the teachers themselves may act as the experts. The role of the expert is to provide a framework for the problem-solving in EL. Mediating tools and techniques are also to be provided by the experts. The idea here is to bridge the gap between the knowledge of the experts and the students. In addition, the experts should also provide an opportunity for the students to play multiple roles.

**Tools**: In EL in primary schools, communication has to be supported between the students, teachers and the environment. An important aspect is that these tools must support the collaborative learning of the students. So, the internet, computers, electronic gadgets, etc., can be the tools used to support EL.

Hung et al. (2006) posit that the EL framework also has staged processes and is similar to a cognitive apprenticeship where the learning is linked to the interface between the mentor and the protégé or teacher and student. A cognitive apprenticeship gives importance to a sort of participatory learning and it takes more than one for learning to take place. Several researchers have supported this form of thinking, associated learning with the settings and opined that learning is more of a social phenomenon than being restricted to an individual (Varela et al., 2015; Hajli et al., 2013; Poellhuber et al., 2013; Lave & Wenger, 1991 and Maturana, & Verala, 1987). Considering the cognitive aspects and social dimension to learning, the framework of EL provides conceptual clarity regarding the essentials of the components of EL.

### 3.3.2. The NSSE Model of EL

Coates (2010) through the National Survey of Student Engagement (NSSE) describes EL as a multidimensional construct which is a mixture of both the academic and non-academic aspects. According to this model, there are five dimensions to EL which are explained in the following paragraphs (figure 3.2).

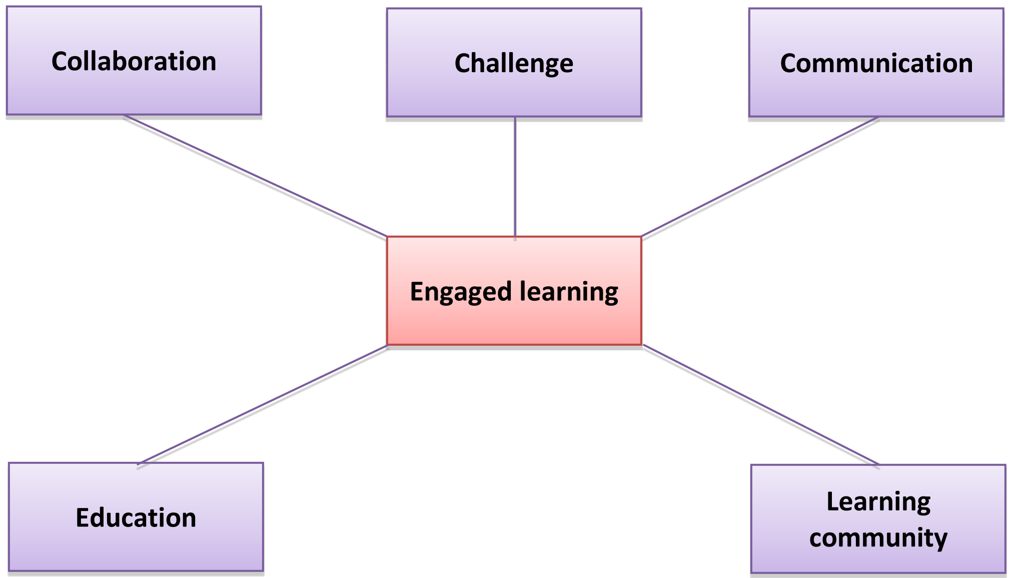


Figure 3.2: NSSE Model of Engaged learning (Source: Coates, 2010)

**Collaboration** – This basically refers to the active learning in groups through mutual collaboration. Collaborative learning is basically derived from the Constructivism theory which claims that students construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences (Thirteen Ed Online, 2004). As and when the students encounter a new situation, they need to compare it with their previous experiences and change what they believe and accept the new information, or even discard the new information if, according to them, it is irrelevant. The concept is that the learners themselves are the active creators of their knowledge. This can never take place unless the students themselves ask, review, seek information, discuss, generalize, comprehend and then accept it as new knowledge. So, the social set-up in which the learning takes place has an important bearing on the amount of learning that has taken place. Further, just knowledge is not on focus, but the student's skill in eliciting information and also the right attitude of the student towards assimilating knowledge plays a role in student learning.

According to the constructivist theory of learning, which is the basis of collaborative learning, learning from the external environment is influenced by several factors and it may even vary based on the learning styles of the students. Cognitive styles of learning have their roots in experiential learning and are closely tied to the constructivist theory of learning (Kolb, 2005). Collaborative learning also leads to experiential learning in which learning is a process and not a product, involving the development of inquiry skills and referring to the acquisition of knowledge rather than just memorizing it in a given context (Solvie & Kloek, 2007). Learning is thus related to the socio-cultural settings in which students critically examine the content, extend their knowledge, and use it to create new knowledge through experiential learning. According to Kolb (1984), learners pass through four stages of the learning process: concrete experience, reflective observation, abstract conceptualization, and active experimentation. In classroom teaching, there are many different ways in which the constructivist approach can be developed. The students can be asked to experiment on real world problems, elaborate on the basic definitions, create more knowledge on what is taught through their own methods, and finally reflect on and discuss how their knowledge on the subject keeps changing and what actually makes them think differently. This kind of experience sharing will provide teachers with adequate information on what inputs may be required for the students to create new knowledge. Various personal experiences of the students combined can create a basis for the generalization of collaborative learning towards a teaching-learning process and, the more such experiences are shared and discussed, the more the teacher can learn to teach. Ultimately, the students' ability to create new knowledge needs to be promoted by the teacher, and hence there is a need to experiment with the students' experiences, which form the basis of collaborative learning.

**Challenge** – The participation of the students in challenging academic activities is one of the indicators of EL. When the students are actively engaged in the process of learning, they enjoy taking on challenging academic tasks. Student participation in challenging academic activities demands a number of characteristics on the part of the student, such as attention, interest, involvement, participation, perseverance, and a desire to acquire knowledge (Trowler, 2010).

The attitude of the students towards the skills expected of them plays a major role in ensuring their attention and involvement with regard to challenging tasks in which they must engage as part of their learning, and teachers have a large amount of control over this (Prensky, 2005 and Liberante, 2012). This demands a lot from the teachers, as they have to know their students well, so that the planning of challenging activities is appropriate for the variety of different abilities within the learning environment (Churchill et al., 2011). When teachers pursue positive relationships with their students and plan class work that enables students to construct their own meaning, students are more likely to behave and participate effectively in learning tasks.

When student engagement is prompted by a desire to accept academic challenges and learn more, students will go that extra mile to extend the studies beyond the classroom and library and may need to find the methods and means to assimilate the required knowledge from various sources, such as relatives, friends, neighbours, and the whole society (Adeyemo, 2010). So, this leads ultimately to the ability of the student to communicate, which will be discussed next.

**Communication** – Most of the knowledge transfer occurs through communication in one form or another. This communication may be verbal or non-verbal. The students communicate in schools through all four forms of communication: reading, writing, listening, and speaking. EL demands all four of these forms of communication. In a survey conducted by NSSE, it was revealed that 27percent of the students were poor in writing skills (94 percent of the teachers expressed that this was very important) and 13percent of the students were considered to have poor reading skills (87 percent of the teachers indicated that this was very important) (Trowler, 2010). Many researchers on the field of communication opine that, for positive communication to take place in a learning environment, there must be an open form of communication whereby students feel free to interact with each other without any inhibitions. It is again the responsibility of the teacher to create an environment in which the students feel free to communicate. Communication in schools is manifold. Teachers are supposed to develop a range of practices and strategies to promote effective communication between students and also between teachers and students.

**Education** – The central focus of EL is education. The outcome achievement in terms of educational objectives is the purpose of any teaching-learning practice. While students are being educated, two extreme situations become possible. The first is positive, healthy, productive, contributing, efficient, and effective, whereas the other extreme is negative, unhealthy, unproductive, non-contributing, inefficient, and ineffective (Trowler, 2010). While the former enables students to become educated about a topic or course, the latter distracts them from it. Kuh et al. (2007) opine that positive student engagement should lead to the participation of students in educationally effective practices, both inside and outside the classroom, and there could be a set of measurable outcomes regarding the achievement of the objectives. Krause and Coates, (2008) stated that it is the quality of the educational outcomes achieved by the student engagement which has to be considered as important when judging the effectiveness of the teaching-learning process or the medium used to educate the students.

**Learning Community** – Student engagement must constitute a learning community in which the students exchange ideas and generate knowledge between themselves (Trowler, 2010). It could be discussions about the gadgets they use for learning, or the topic being studied, the difficulties they face, the better way of learning, the easier method of achieving the outcome and several such creative methods of learning. The concept is to make EL a tool for promoting student interaction. It is not the topic which they discuss during the interaction that is important, but the knowledge generation process that matters. Once the student engagement through a particular teaching-learning process enables the development of a learning community, the process of knowledge generation begins automatically and the students will become part of the system.

### 3.4. EEG and Student Engagement

Student engagement has been an area of research interest to many. The main reason why EEG is gaining popularity in the educational field in the context of learning is that it can 'actively engage' the students in the process of learning. Dewry (cited in Ang & Wang, 2006) emphasized the need for the active EL of the students through a natural process of inquiry. EL may be defined as, "the mobilization of cognitive, affective, and motivational strategies for interpretive transactions with text" (Bangert-Drowns & Pyke, 2001, p. 215). Here, the cognitive domain is the thinking part of learning, the affective domain is the emotion/feeling part of learning, and the motivational domain mainly refers to the attitude towards learning. Any EL should consider all three of these components of human learning. Researchers have discussed several instances related to the capability of EEG to influence all three of these domains of learning. Jones et al. (1994) suggested the following characteristics of EL. Engaged learners take responsibility for their learning, find it exciting, and take pleasure in it. The tasks will be challenging, multidisciplinary and deeply interesting. The assessment will be purely performance-based and learners will be able to understand their performance progressively. The assessment is also generative and of equitable standards. The instructional strategies are generative as well as interactive. The context is a knowledge-building learning community and collective learning is promoted. The groups chosen for EL are flexible and heterogeneous. The most positive aspect of EL is that the student will be in the driver's seat and the teacher will act as a facilitator of learning who can be a guide and co-learner, whereas the students become explorers, cognitive apprentices, and generators of knowledge.

Information and Communication Tools (ICT) play a special role in meeting the characteristics of EL, as mentioned above, however too much exposure to ICT may be a 'turn off' for pupils. Boud and Felleti (1991) and Savery and Duffy (1995) state that ICT can assist greatly when problems are ill-structured, offer challenges related to formulation, and complex in nature. The most important contribution that ICT can make to EL is to support all three types of interaction required by the learner i.e. learner-content, learner-learner, and learner-teacher (Moore, 1989 and Chou, 2003). It is the interaction between the individual and collective memory that makes knowledge acquisition progressive. In terms of the collective memory, the teacher's knowledge will also be a part of the collective memory from which the students can draw information and knowledge. EEG makes a special contribution in the context of collective memory, as students can work in groups to share ideas, negotiate solutions, and create knowledge for both themselves and their co-learners collaboratively. Moreover, an EEG-based learning environment can make use of ICT tools which often involve more generative work, in which students produce multimedia programs, websites, concept maps, or presentations. Many researchers have identified the EL that takes place in the environment of EEG. Swan et al (2005) proved that students' motivation towards EL improved through EEG. Kadakia (2005) observed the process enhancement of EL when the students indulged in EEG-based learning. Lim and Tay (2003) observed student involvement in the analysis, synthesis, and evaluation (Higher Order thinking Skills) during EL through the use of EEG. All of these studies indicate that EEG has the ability to promote EL and that EL has a higher goal accomplishment in relation to knowledge creation and utilization.

It is believed that EEG can improve student engagement for several reasons. It is observed that several principles are followed by EEG, appropriately supported by the relevant mechanisms (Perrotta et al., 2013). The first principle is that the game is designed to motivate the student intrinsically, so the student plays voluntarily and is self-driven to play the game. The second principle is that learning is designed to be accompanied through intense enjoyment and fun. The third principle is that the game is contextualized and purely goal-oriented in its approach, and that there is no scope for abstract thinking. The fourth principle is autonomy in the playing of the game. It is the passion and the interest of the students which makes them develop a desire to specialize. The final principle is that EEG is based on experiential learning which means that it is learning by doing. Students perform a task and then revisit the entire task to check where they performed well and how they can improve upon this. All of these principles are well supported by the mechanisms. First of all, a simple binary rule is followed in the game, e.g. yes/no or multiple choice. EEG offers clear but challenging goals. There is a mechanism of a fictional setting which encourages the students to use their imagination. The levels in the game are designed to be progressively difficult so that the students can continuously improve until they reach the top level of academic performance. There are mechanisms which permit the interaction of the students as well as a method to control. The game gives immediate and constructive feedback to the students. There is a social dimension attached to EEG so that the students can interact with each other and exchange their views about their experiences with EEG. These principles supported well with the mechanisms if closely observed aim towards the student engagement.

Perrotta et al. (2013) note that, in terms of the social-dynamics of EEG, a common observation is that this tool successfully develops a form of ‘affinity group’ among the students who voluntarily come forward to exchange their ideas and views about the excitement they experienced when using EEG during the learning process and these shared thoughts start to enter the student community and go viral, thus making more students use EEG more positively. This reinforces the idea that it is collaborative learning that is the strength behind EEGs. As the students develop a positive view about the usage of EEG in learning, they too will focus their attention on EEG and thus their engagement with the game will improve on a continuous basis.

Researchers such as Gee (2008), Shaffer (2008) and Bogost (2011) have observed that the EEG has distinct properties, such as the use of games as the medium of learning, the ability to simulate certain behaviour and experience, being governed by a set of rules, following certain principles, and containing reward mechanisms to motivate students, which truly enhance student engagement.

## 3.5. Teacher Characteristics and Student Engagement

Teacher characteristics are those specific attributes and traits of teachers, which can be measured through tests, academic profile and questionnaires served to the teachers, which are responsible for student engagement and student performance (Kosgei et al., 2013). These characteristics may not be directly observable as being responsible for student performance because they may even include traits based on personal psychology. However, these characteristics are directly observable during the selection interviews to a great extent. Some of these characteristics may be demographic characteristics, such as age, gender, experience, qualifications, background, etc., whereas others may include aspects such as certification status, credentials, contribution to the body of knowledge, conferences attended, conference papers presented, workshops attended, journal papers published, etc.

This research focuses on the influence of EEG usage in primary education on student performance from both the student and teacher perspective. Only this kind of two-fold approach can provide a complete picture of the current situation. Education is a continuous process of refining the knowledge and collective values embedded in society and preserving it for future generations (Oyekan, 2000 and Omotayo, 2014). So, it is the collective input by all of the stakeholders in the educational institutes, which include students, teachers, parents, business organizations, as well as the whole of society. Education in one sense is also the refinement of human attitudes and behaviour in terms of reasoning, rationalizing, and enhancing the quality of life as well as preserving nature. Primary schools can be the very first time that students are exposed to education, and it builds the foundation for their learning process. Education is not an individualized process but a collective one, in which learning takes place through the collective efforts of the student, teacher, and the environment. Teachers play a vital role in the students' learning because they form a bridge between the knowledge base and the students. It is in this context that the background of the teachers in the form of their qualifications, experience, specialization, credentials, and demographics becomes important. Unless teachers are in the teaching profession due to a burning desire to generate, assimilate, store, and disseminate knowledge, the objectives of education will be difficult to achieve.

Some researchers have linked teacher characteristics to student engagement and academic achievement (e.g. Adeyemo, 2005; Akinsolu, 2010; Olaleye, 2011 and Kosgei et al., 2013) and have identified several teacher characteristics which have a bearing on student performance, including teachers' personality (Adu and Olantundun, 2007), qualifications (Akinsolu, 2010), attitude (Wirth & Perkins, 2013), and administrative ability (Patrick, 2005), as well as factors such as age, gender, experience, educational background, personal qualities, and national teacher examination test performance (Kosgei et al., 2013). These researchers have found through their studies that these characteristics have a bearing on student engagement and hence student performance. It is important to note that there is an important difference between ascribed characteristics and achieved characteristics. Ascribed cannot be changes whereas, the achieved can.

Teacher qualification is an important indicator of teacher performance and so a contributing factor with regard to student engagement and achievement, but nevertheless these factors alone are inadequate for meeting the students' requirements and keeping them engaged. Teacher qualifications refer to the certification of teachers to teach a course on their major (Darling-Hammond, 1998). These factors can only decide how well they may be able to teach in class but offer no guarantee of student engagement. Teacher characteristics are related to the mental ability of the teachers, which is based on a combination of several factors related to their attitude, behaviour, nature, determination, desire to help, and emotional stability (Owoeye & Yara, 2011 and Huang & Moon, 2009). Research has indicated that about 40-60 percent of the variance in student achievement is based on teacher qualifications (Huang & Moon, 2009). Richardson (2008) found that the students in urban areas performed far better than those in rural areas, which he attributed to the fact that more qualified teachers are available in the urban areas and so indirectly established a relationship between teacher qualification and student performance. Owoeye and Yara (2011), however, found that students in the rural areas outperformed those in the urban areas. However, many researchers are of the opinion that qualifications and experience are merely the entry level requirements for teaching, and that the ability of the teacher to achieve student engagement demands many other qualities, among which teacher training is important (Ruthland & Bremer, 2002; Darling-Hammond et al., 2002). Goldhaber and Brewer (2000) found a positive relationship between teacher qualification and student performance in mathematics, but not in science. So, it cannot be concluded that teacher qualification necessarily improves student performance and the research continues. It appears that, even if teachers are knowledgeable about the content of the course which they deliver in class, the dissemination of that knowledge from the teacher to the students in various forms (verbal, visual, audio, media, experience etc.) has a bearing on the environment, which facilitates learning and the specific traits of the teachers which enable them to facilitate the process of learning. Teachers must to create an environment which is congenial to student engagement and continuously learn to identify and eliminate the barriers to this. While many teacher characteristics influence student engagement and performance, not all have an equal influence.

Teacher experience is also considered an important characteristic which has a bearing on student engagement and performance. Research has shown that experienced teachers have insightful experiences to share with students, have revised their course delivery several times, and have evolved into effective teachers over a period of time and so can contribute more to student engagement and performance (Kosegei et al., 2013). Early research on teachers' experience proved that experienced teachers can produce better student performance because they are aware of more appropriate ways to teach, possess better classroom management skills, and are better able to cater for the heterogeneous nature of the class in terms of intelligence, knowledge, background and mental maturity (Stringfield & Teddlie, 1991 and Gibbons et al., 1997). More specifically, Rivkin and Kain (2003) found that teachers with three years' teaching experience or less were less effective than those with more teaching experience, and also that brand new teachers were the least effective of all. Agbatogun (2010) found that, when a higher number of experienced teachers were present, the student achievement improved and the number of dropouts from the school fell. Research has also proved that the first year of teaching enables teachers to enhance their teaching skills considerably, but that the amount of gain slows in subsequent years (Omotayo, 2014). Researchers have identified teachers' motivational level and amount of training during their experience as the contributing factors which enable them to teach better and so enhance student performance (Fullan, 1992 and Kosegei et al., 2013). Several studies have found that, the higher the experience of the teacher, the better the student performance (Rivers & Sanders, 2002; Clotfelter et al., 2007; Stronge et al., 2007). It is also noteworthy that the influence of teachers' experience on student achievement is less than that of other characteristics, such as their content knowledge and overall academic ability (Agbatogun, 2010).

Student engagement is mainly a function of three dominant variables: behavioural engagement, emotional engagement, and cognitive engagement ( Trowler, 2010). A closer look at these three variables reveals that the teacher's knowledge of the subject can control only the cognitive engagement of the student, whereas the behavioural and emotional engagement demands many more characteristics from teachers. These characteristics may be soft skills and social skills which relate to interpersonal relationships, such as problem-solving, decision-making, collaboration, sharing, ideas generation, cooperation, harmonization, coordination, planning, directing, organization, etc., rather than hard skills, that are related to subject knowledge. When students are behaviourally-oriented towards learning, they may conform more to norms such as punctuality, attendance, discipline, involvement etc., but when they are not behaviourally-oriented, they may exhibit absenteeism, slack discipline, a lack of involvement, etc., When they are emotionally oriented to learning, they may demonstrate affective reactions, which include a keen interest, enjoyment of learning, a sense of belonging to the class, a high state of motivation, etc., and when they are emotionally uninvolved, they may show a lack of interest in learning, no joy in learning, indifference to the class, a lack of motivation, etc. The cognitive engagement of the students may be demonstrated through their investment of time in learning, making extra efforts in learning, accepting challenging tasks, engaging in knowledge-seeking behaviour, etc., but when there is no cognitive engagement, students may not spend time learning, may not accept challenges in learning, and may not show inquisitiveness in learning. If there is to be perfect student engagement, students must demonstrate positive behaviour in all three domains of student engagement. The teachers have a considerable role to play in creating an environment that is congenial to student engagement. It can be observed that researchers have categorized the components of student engagement, but have not been successful so far in identifying the specific characteristics of the teachers which may contribute to the individual components of student engagement. It is also observed by researchers that student performance in mathematics did not differ much based on teacher qualification (Goldhaber & Brewer, 2000). Rowan et al. (2002) found that the teachers' possession of advanced degrees did not have any significant influence on student engagement or performance. It can be observed that the research studies do have contradictions in terms of student performance with reference to teacher characteristics. So, the influence of teacher characteristics on student performance must be studied in greater depth to understand its impact on student performance.

### 3.6. Measurement of Student Engagement

Appleton et al. (2008), after radically examining the definitions of student engagement, concluded that there is no consensus among researchers on clear-cut indicators, and hence it is difficult to measure engagement in quantitative terms. One of the earliest measurement instruments of student engagement was the Motivated Strategies for Learning Questionnaire (MSLQ) which was developed to assess college students' motivational orientation and basically focused on the strategies used to motivate students to remain engaged (Pintrich et al., 1991). Later, the Institute for Research and Reform in Education (IRRE) developed a metric to measure on-going engagement, which included the effort, attention, and value the students attached to the topic (IRRE, 1998). Kong et al. (2003) claimed that the instruments were developed to measure the students' level by focusing mainly on the human and physical resources available in schools/colleges rather than on the course content. Hoffman and Nadelson (2010) gave a new direction to student engagement measurement in the form of an empirical study that focused on measuring the three domains of student engagement i.e. behavioural, cognitive, and emotional. They suggested the use of empirical methods, whereby researchers can measure engagement precisely with regard to the three domains of student engagement.

If Student Engagement or EL is to be measured, a clear identification of the dimensions and indicators of measurement are necessary because what cannot be quantified cannot be measured, and what cannot be measured cannot be improved in terms of quality. The primary objective of this research is to improve the quality of student learning in the context of modern technology usage. So, it is quintessential to research the measurement issues related to EL.

The National Survey of Student Engagement (NSSE) initiated in the year 2000 identified several measurement indicators of EL (Kuh et al., 2003) to determine the extent to which students are engaged in learning and what they gain from EL. Thus, NSSE focused on two aspects of EL namely, the behavioural aspects related to student engagement and the effective educational practices that supported these behaviours. NSSE considered the term 'engagement' as a synonym for 'involvement' in the context of learning and considered it to be the psychological and physical energy expended by the students in learning (Kuh et al., 2003). The physical aspects included efforts such as listening, speaking, interacting, observing, participating, attending, articulating, presenting, etc., whereas the psychological aspects included thinking, decision-making, analysing, synthesizing, contemplating, comprehending, etc. (Dumont et al., 2010; Hossler et al., 2001 and Kuh et al., 2005). Behaviour has been conceptualized as the nature of the interaction between a person and the environment (Kuh et al., 2003). So, for EL to take place, both the environmental support provided by the facilitators and the infrastructure, and the motivation and cognition occurring within the student become important. NSSE emphasized the identification of specific indicators under both the behavioural and environmental factors which contribute to EL.

Kuh et al. (2003) recommended a multidisciplinary approach with three different theories to make the measurement of EL more meaningful: intrinsic motivation and self-determination theory (Ryan & Deci, 2000), mindful learning (Langer, 1997) and flow theory (Csikszentmihalyi, 1975). The intrinsic motivation and self-determination theory postulates that those with intrinsic motivation are likely to be ready to exert more energy in learning through perseverance and participation for a longer duration. Mindful learning emphasizes the psychological presence of the student in the current situation and look for something that is new. Novelty captures the attention of the students and they try to assimilate all the information about it when learning takes place. Flow theory emphasizes the students' ability to work continuously without losing concentration, with total involvement in the subject matter. Thus, these three theories provided a means for measuring the quality enhancement of student achievement through EL.

The above three models provide a means for measuring EL effectiveness at the macro level. The micro level measurement was introduced by Handelsman et al. (2005), who proposed the emotional and participation or interaction of the students with clear measurable indicators. While the emotional aspects of the measurement deal with the feelings of the students, the participation aspects deal with the students' social aspects which can include soft skills. This model provides immense scope for measuring student capability enhancement in terms of improving their motivational level, ability to create interest in the course being taught, communication skills, analytical skills, etc., at the micro level. Measurement can be either qualitative through observation or quantitative through hypothesis testing. The research on measurement issues finally led to the development of the EL Index (ELI) which measured student involvement, engagement, flow, mindfulness, intrinsic motivation, and deep learning (Taylor & Parsons, 2011; Tagg, 2003; Kuh et al., 2005; Ryan & Deci, 2000). All these studies have bearing on the measurement issues of the current research which is discussed in the next section.

### 3.7. Measurement of Teacher Characteristics

Researchers have examined the teacher characteristics which influence student engagement and performance and found that characteristics such as academic ability, certification, expertise in the subject, and experience have an important bearing. However, the search for teacher characteristics has been ongoing, as the very process of teaching-learning is undergoing constant refinement. Moreover, the previous studies on the identification of the specific teacher characteristics which influence student engagement and performance have produced inconsistent results (Guarino, 2006), which has proved a severe impediment to the development of a measurement instrument for teacher characteristics.

Several researchers have identified the teacher characteristics which play an important role in student engagement and student achievement, such as academic background (Clotfelter et al., 2006; 2007; Harris and Sass, 2006), admission test scores (Kosgei, 2013; Dobbie, 2011), certification (Boyd et al., 2008; Goldhaber & Emily, 2007), designation (Emily, 2007); educational level (Okpal and Ellis, 2005), personality characteristics (Woolfolk & Hoy, 1990 and Hoy & Woolfolk, 1993), academic ability (Guarino et al., 2006), teacher attitude (Schaeffer et al., 2002 and Okpal & Ellis, 2005), instructional practices (Guarino et al., 2006), experience (Kosgei, 2013), pre-service training (Guarino et al., 2006), courses taught (Boyd et al., 2008) and demographics (Ashton, 1996; Kosgei, 2013). Some of these characteristics can be measured directly from the profile of the teachers while others need to be elicited through questionnaires or face-to-face interviews. Standard instruments are also available for measuring these characteristics, among which the Teacher Qualification and Experience Questionnaire (TQEQ) (Omotayo, 2014) is very popular.

The context of this research is EEG-based learning in the individual and collective mode, so it is important to identify these specific teacher characteristics which have a bearing on this specific mode of teaching/learning. So, the screening of the aforementioned teacher characteristics led to the identification of the following ones: education level, age, gender, designation, teaching experience, course taught, and the electronic games used by the teachers. The educational level of the teachers has been considered because, regarding EEG usage, the teacher needs to be techno savvy and have a decent background in computer usage at a higher level of education. It is unlikely that a computer-aversive teacher would encourage and facilitate the usage of EEG. Even though research has yielded inconsistent results on the influence of educational level on student performance, the importance of the educational level of the teacher can never be underestimated in the context of teaching. Age and gender are the two demographic factors considered in this research because it has been observed that older teachers are relatively less-oriented towards electronic games compared to younger ones. The gender of the teacher may also influence student performance and, as this is one of the areas of focus in the current study, teacher gender is also considered as an exogenous variable. The designation of the teacher is also an important characteristic to be considered, as the teacher needs to strike a balance between his/her academic and administrative responsibilities. So, it would be interesting to study the influence of teacher designation on the EEG usage of the students. Research has shown that the teacher's experience has a bearing on student performance, and hence this is also considered in this research to see if this concept is applicable in the context of EEG usage also. The course taught by the teacher may be another variable which influences the EEG usage of students because not all courses may benefit from this, as perceived by the teachers. Thus, the course taught by the teacher has also been considered as a teacher characteristic in this research. Finally, the early exposure of the teacher to EEG may influence his/her perceptions of EEG usage's effectiveness and hence this is also considered as a variable in our current study.

## 3.8. Conclusions

It can be concluded from the literature review that EL is a combination of 'learning by doing', 'inquiry-based learning' and 'constructivism'. This implies that, in EL, students must work meticulously on an exercise or problem of some kind and, as he/she makes progress, learning must occur naturally. It can also be considered to be a teaching philosophy that the student plays the role of an explorer who develops a series of questions then seeks to answers these during the expedition which takes place in a collective mode where he/she has an opportunity to interact with his/her peer group, environment, and teachers. It is necessary for students to develop a set of soft skills so that they learn how to learn through their surroundings and become lifelong learners. They need to stay motivated throughout EL and also motivate others, as collective learning must take place. The literature also indicates that knowledge has to be constructed, created, or generated by the students and applied to the given problem situation. A very clear set of indicators have been developed by researchers in order to make EL more effective in terms of achieving objectives, which includes vision, tasks, assessment, mode of delivery, learning context, grouping, the role of the teacher, and the role of the student. EL can succeed only when the overall combination of these indicators is in tune with the desired goal of EL usage.

There is also literature support for a framework of EL which considers six components, namely: problem, tools, ownership, collaboration, monitoring, and experts. The framework provides the essential features of EL and shows how it can be adopted in the educational setting. The literature on EL also covers measurement issues, and three major theories have been combined to develop specific indicators of measurement, which are: self-determination theory, mindful theory, and flow theory. At the micro level of measurement, the emotional and participation or interaction of the students is considered important. To conclude, EL is a highly-structured form of learning which is scientifically based on many different theories. Researchers consider it to be an effective form of imparting knowledge on a course; however, its success is based on the ability of the knowledge providers to provide the right kind of environment where learning can take place. The discussion of measurement issues in connection to student performance as well as teacher characteristics helped to develop the rationale for the choice of measurement instrument for this research.

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# CHAPTER 4

# Individual and Collective Learning

## 4.1. Introduction

This chapter highlights the approaches of individual and collective learning, and discusses the eight different conceptual orientations related to this phenomenon. The theoretical perspectives on individual and collective learning are discussed relative to each other, as are the electronic games and gender-related studies related to this phenomenon.

## 4.2. Individual and Collective Learning

Great progress has been observed round the globe on individual and collective learning processes, among which EEG-based learning is very popular in the context of primary education.

The EEGs have been designed to serve a specific purpose. Griffith (2002) found that communication skills in children and adolescents were considerably developed when they were encouraged to use EEG in groups. Two types of communication are promoted in EEG: that of an individual with the EEG and that between classmates. The EEG also had an ego-boosting and self-calming effect (Gaylord-Ross et al., 1984). EEGs provide the visual patterns and speed that promote children's basic skills development. Some of the therapeutic benefits that have also been recorded include: language, mathematics, reading, and social skills (Griffith, 2002). The effectiveness of EEG is based on several factors: educational objective, type of game, nature of involvement, information and rules, difficulty level, competition, duration, teacher background, number of players, facilitator's role, and setting. Typically, there are two types of EEG environment: Individual and Collective.

Individual EEG: In this mode of EEG, the student will work individually on the EEG. A set of instructions will be given to the student at the beginning of the game and then the students will play it independently (Saffarian & Gorjian, 2012). There will be sequential operational procedures which the students will follow on an individual basis; on the accomplishment of the task, automatically the learning also takes place. The interaction in this case will be between the human mind and the electronic gadget.

Collective EEG: In the school, most of the learning as well as evaluation are based on an individual basis but, when they start their professional career, they will have to work in groups and operate collectively. So, unless they are taught to work in groups, the schools will not prepare them for their future professional career. With this in mind, collective learning through EEG was designed (Papargyris & Poulymenakou, 2010). In collective EEG, students are divided into groups of six and a task is given to them through the EEG. They are supposed to discuss it with each other and solve the exercises provided. During this exercise, those students who are fast learners will teach the slower learners. Thus, the learning will take place in groups and the interaction will be between the individual, the electronic gadget, and the group.

The available literature highlights eight different conceptual orientations regarding individual and collective learning. These will now be discussed in detail.

#### 4.2.1. Individual Knowledge Acquisition (IKA)

This refers to the storage of the knowledge, skills, and attitudes acquired from acquaintances in the minds of individuals which will be used to meet future requirements (Nafukho et al., 2004). In this process of learning, the individual has to assimilate the knowledge and incorporate it into his/her behaviour. This knowledge can be passed between individuals when the knowledge is demanded by others and the person who possesses that knowledge is ready to share it. This kind of knowledge is acquired cognitively, which could be by listening to others during the information presentation, and then applying it in real-life situations (Hutzschenreuter et al., 2014; Bates et al., 2004; Enos et al., 2003 and Weithoff, 2004). Gherardi (2000) and Hager (2004) opine that this type of knowledge is more practice-based and that repetition is the best way to acquire individual knowledge. When students engage in EEG, IKA will occur under two separate scenarios. The first is when they interact with the electronic games, and the second is when they interact with others. During both these activities, IKA occurs and, as discussed previously, the schemata in the minds of the students is reformed.

### 4.2.2. Sense-making and Reflective Dialogue (SRD)

This is the learning that takes place as the reflective meaning-making that takes place when students participate in EEG-related activities. Learning basically involves the formation of completely new or altered meanings in the minds of learners. The students need to progress through a series of activities including identifying the problem, choosing from alternatives, decision-making in different situations and creating solutions (Latemore, 2015). The nature of the reflections in which the students engage is based on their earlier experience and the type of interaction they have with both EEG and their classmates as well as teachers. When individuals enter into a reflective dialogue in their mind, it will be a reflective thought that is created which enables them to create the schemata for future reference. When collective interactions take place, these prompt collective reflection and agreement/disagreement with the self and the group which make learners form or alter their understanding of the concepts. In some cases, the story-telling will also lead to collective learning through reflection. However, group critical reflection, dialogue, and enquiry form the building blocks of learning that takes place (Snell, 2002; Abma, 2003; Svensson et al., 2004; and Jørgensen, 2004).

### 4.2.3. Network Utility (NU)

Networking is now becoming a very popular mode of communication as well as the paradigm for learning. During the process of collective learning, students form their own networks and exchange ideas, based on which their individual learning occurs. Later, when they interact with the entire group, the learning which took place through networking and then in the group may sometimes be contradictory, which forces them to think further and critically evaluate their understanding of the rules and principles which created the knowledge. What occurs at both levels is ‘knowledge transfer’ or ‘diffusion’. Some kinds of knowledge are more effectively transferred through networking (Wellman et al., 2014; Brown and Duguid, 2002). Individual-collective interaction in the EEG setting is very similar to this and students do network with each other both during and outside the sessions and also discuss the learning that takes place. Researchers have also linked sociocultural issues to NU and argued that the learning dynamics are governed by these issues. Individuals and the network members share their knowledge and ideas if these are valued and supported, which leads to some kind of reward in terms of either appreciation or gratification. Students who gain proficiency in EEG will have a natural desire to share their knowledge with others and, if the team dynamics is congenial to learning, considerable ideas exchange is possible (Cabrera & Cabrera, 2002; Letiche, H. & van Mens, 2003 and Currie & Kerrin, 2004).

### 4.2.4. Levels of Learning (LOL)

ICL is considered as separate, distinct levels and forms of learning and may or may not be intertwined or participation-based. There can be several LOL in the ICL that takes place in an EEG-based environment. Researchers have proposed different models to distinguish between the levels within which individuals and groups may act. Scarbrough et al. (2004) propose a nested composition of teams when people collectively participate in learning. Some may be attempting knowledge exploration while others may consider knowledge diffusion. The model proposed based on the analysis of learning shows that learning can take place at three levels i.e. individual, team and class, and four processes can be considered to interact at these three levels i.e., intuiting, interpreting, integrating and institutionalizing (Franc & Morton, 2014 and Lehesvirta, 2004). Individuals may follow their intuition when there are multiple ways to tackle a problem. They may interpret the concepts of mathematics in accordance with their schemata, or even integrate the knowledge they collect at the group level. In addition, they may filter their new/altered knowledge in various ways and institutionalize the same for future reference. Brady and Davies (2004) adopt a different approach, suggesting four different LOL phases which occur; viz., innovation, criticism, sharing, and routinizing. Students may seek an innovative approach when encountering a task and, during the interactions, may share it with their group. It then passes through the phase of criticism and the students may consider this knowledge as standard or change it and then routinize the same and the learnt behaviour. The learning phases here are individual-task, task-task, and task-team. Thereafter, the knowledge will be shared among the group members and routinized for future use. So, there are many different LOL approaches to learning when EEG is used on an individual-collective basis, and there is scope to study which approach would be the most appropriate in the context of primary education.

### 4.2.5. Individual and Human Development

This is based on the humanist philosophy which states that, by their nature, human beings desire continuous growth (Dutta, 2014 and Cabrera & Cabrera, 2002). Researchers also argue that, in this philosophy, the priority of the individual will be to update his/her self-knowledge first through individual-collective interaction and then attempt to educate the rest of the group (Jacobs and Washington 2003). This relates to the theory of constructivist learning, whereby the individual undergoes a transformation through reflective thoughts base on the background and sense-making ability coupled with a desire to learn continuously as well as educate others. Straka (2000) opines that an individual's self-directed learning ability and the ability to understand the importance of educating the team plays an important role in the learning process.

### 4.2.6. Individuals in Community

This perspective on ICL is based on viewing an individual as a person identified by well-defined boundaries from the community and the ability of the individual to assimilate knowledge and skills from the community. According to this concept, learning is portrayed as the effect of the social, cultural, and cognitive ability of the individual. There are aspects such as trust, understanding, and cooperation among the members of the group which define the success of learning that takes place at the individual level (Davis et al., 2000). A sort of 'relational dynamics' defines the governing philosophy of this perspective. The role of the individual is to give ideas and the role of the environment is to discuss these ideas and generate knowledge. The environment here only acts as a mediating factor between learning and the individual. Several research studies have sought to define the environments which are positive and support learning and those which hinder learning, respectively (Filstad, 2004).

### 4.2.7. Communities of Practice

According to this concept, learning is though participation in a community which is interested in achieving a common goal and has a cultural dimension associated with it (Eric et al., 2014; Driver, 2002; Yanow, 2000; Bogenrieder and Nooteboom, 2002). In communities of practice (COP), learning is considered a group activity while learning at the individual level is given relatively less importance; hence, individual differences, perception bias, the intellectual abilities of the individuals etc., are not counted. Research is in progress to find the means and methods to improve the efficiency of COP. Bogenrieder and Nooteboom (2002) have identified that trust among the members of the COP, the willingness to share new ideas, and the group structure play an important role in the success of COP. This indicates that the students should be first trained to be more cooperative with each other rather than competing with each other. Even though COP tends towards the collective mode of learning, it should be noted that, as group learning takes place, individual knowledge is also updated and the interactions make the students go through the entire process of defining the problem to arrive at the solution.

#### 4.2.8. Co-participation or Co-emergence

According to this concept of ICL, the mutual interaction leads to the modification of individuals' perceptions, beliefs, attitudes, understanding, approach, behaviour, and the entire perspective on a topic which is being studied (Borgatti et al., 2014; Billett, 2004; Salling, 2001). The principle states that participation in the group activity itself leads to the emergence of a new self but there is a view that making a student participate in a group activity is challenging. It is only the students who are motivated to learn and have ideas to share who participate and lead the discussions, while the rest will remain dumb spectators. So, co-participation and co-emergence can take place only through the efforts of the facilitator who has the ability to motivate the students to participate in the group activity (Gherardi and Nicolini 2000). Another group of researchers argue that this need not necessarily be the case because even silently listening to the conversations of other students might lead to the emergence of new concepts in the mind of the students (Elkjaer, 2003).

All of the above eight categories of ICL are unique and explain the learning dynamics in their own way. It should be noted that context plays an important role in the applicability of a particular model, as discussed above. The background, motivational state and the setting in which the EEG is practised may also influence the type of learning which may be affected. The purpose of this research is not to distinguish between these individual models which explain ICL but, rather, to study in depth the changes that EEG can bring about in primary school children.

However, each of the models becomes important as it gives the learning philosophy in the individual-collective forms.

## 4.3. Theoretical Perspectives on ICL

The literature indicates that there are four perspectives in the study of the process of learning: behaviourism (Weegar and Pacis 2012; Ertmer, P.A. and Newby, 2013), cognitivism (Tellefson, 2000; Schneider & Stern, 2010), pragmatism (Gordon, 2009; Kickman, 2009 and Jayanti & Singh, 2009) and social constructivism (Taber, 2011; Rummel, 2008; Liu & Matthews, 2005 and Swan, 2005). In addition to these four perspectives, there are also many other theories which have a bearing on the concept of individual collective learning.

According to the theory of behaviourism proposed by Skinner and Watson, who basically studied the relationships between ‘organisms and the environment’, the behaviour of the learner can be predicted and controlled through the learning environment (Weegar and Pacis, 2012). Behaviourism is a positivist approach which proposes that the environment can be considered the stimulus and learning the response (Webb, 2007). Skinner went beyond the stimulus and response concept in the case of the environment and learning to claim that, in addition to the influence of the environment, the background of the students also has an influence on the learning that takes place (Weegar and Pacis 2012). This is true to an extent or else, under the same environment, all students would produce the same results, which does not happen in real life. This is exactly where ICL constitutes a difference in the achievement of the educational performance outcome. In the case of individual learning, the environment will be the same for all students but the background will be unique to each one. In the collective mode of learning, the student may have an additional influence on learning through the inputs received from other students who have a diversified background and different prior experience. According to behaviourism theory, only the observable and measurable external behaviour is worth considering in learning (Bush, 2006). In the proposed research, an attempt has been made to assimilate the observable behaviour through interviews with the students and a measurable outcome has been obtained from their performance in the ICL.

Cognitivism is concerned with the study of an individual student and teacher's beliefs about student performance, and the study of how these beliefs influence the student-teacher relationship (Tellefson, 2000). According to this theory, students go about the school and look for tasks which leads to their successful achievement of educational outcomes. It is these personal characteristics which they presume to be necessary for defining their success. Cooper and Good (1983) called this the attribution-behaviour link and conducted an in-depth analysis of it in many different classroom settings. While some students may feel comfortable about working on tasks individually, others may prefer to work in groups. The attribution-behaviour link may different under the individual and collective modes of working on a task. Cooper and Good found that students regard their ability and effort to be important factors in achieving success. Further, they also found that the amount of effort that students perceive to be exerted will always be under revision by the students. It is imperative that the attribution-behaviour link is different for ICL. When, in the individual mode of learning, students only have their own set of ideas regarding whether they can successfully complete a set of tasks, under the collective mode of solving a problem or developing a concept, the group will be more resourceful. Cognitive theory, according to the findings of Tellefson (2000), offers a basis for understanding the students' perceptions about their success in achieving the educational outcomes which can provide clues on how to change the student/teacher interaction pattern in order to achieve better student results.

Pragmatism-based learning theory is grounded in the theory of transforming what is known into action to produce a particular behavioural response (Jayanti & Singh, 2009). Pragmatism consist of deliberate, iterative, and socially-constructed inquiry-based processes. It may involve the concept of reflecting on, refining, and exploring the problems. According to this theory, both individual and collective efforts may be required on the part of the learner to achieve the desired educational outcome (Gordon, 2009). It is this combination of engagement and inquiry-based abilities of students that make learning possible according to the proponents of pragmatism-based learning theory (Kickman, 2009). The iterative cycle of learning, according to the pragmatists' approach, consists of the experiences of the individual which trigger certain inquiries into the problem. This spirit of inquiry triggers the capabilities of the students. When the inquiry is productive, knowledge is generated, and the action will take the form of new problems which need to be solved. While individual learning is supported to an extent by the pragmatic learning theory, collective learning is also supported, as distributed, network-based learning is also a mode of learning according to this theory. Further, while working on an individual basis, the cycle of knowledge generation is restricted to an individual whereas, in the collective mode of learning, the group can contribute much better to the generation of knowledge and the sharing of it among the group.

Piaget and Vygotsky, the two main proponents of Social Constructivism theory, propose that learning is a 'search for meaning' and have developed a theory to identify what students comprehend at different stages of their learning (Rummel, 2008). This relates to how students make meaning out of their experience (Taber, 2011). It is the continuous interaction of the perception of an individual and the knowledge that is generated when a new object is encountered. It is also the interaction between the experiences and ideas of an individual. The constructivist theory explains how knowledge is generated in people's minds and postulates that two processes (accommodation and assimilation) are responsible for this. During assimilation, the new knowledge is accommodated along with the existing knowledge. The student compares and contrasts them and adds to his/her existing knowledge if he/she finds something generative. In fact, the collective mode of learning has been designed to suit the requirements of the social constructivist view, whereby students seek knowledge, assimilate it, try to make sense of it, compare it with their existing knowledge and add the new elements to their existing knowledge.

In a recent study, Anderson and Lewis (2014) examined various factors which can contribute, or distract from learning while individual, collective or both forms of learning take place. Their focus was on studying the influence of the cumulative knowledge of the group on individual learning, and validate the Transactive Memory System Theory (TMST) (Wegner 1986), which describes how learning processes affect individual and collective knowledge and performance. According to TMST, learning influences collective learning which in turn influences individual learning and the cycle goes on.

TMST is a condition whereby an individual has access to eliciting information from others in a group (Wegner, 1986). Kotlarsky (2010) defines transactive memory systems as a combination of a individual memory system and communication or transactions. The more the individual assimilates the knowledge of different members of the group, the greater will be the collective memory of the subject as well as the 'transactive memory' of the entire group. Transactive memory concerns the knowledge about whom should be contacted in a group to elicit particular information or gain specific subject-related knowledge. Wegner (1986) conceptualized two forms of transactive memory: one is the combination of the personal knowledge possessed by a student, and the other is an awareness about who knows what in the team. Cruz et al. (2007) postulate that it is the second part of transactive memory which has to be strengthened to make learning more effective as the individual's knowledge is limited. Learning thus becomes a continuous process which involves the interaction of students with the knowledge they possess and their interaction with others. Communication is the key to knowledge assimilation, according to TMST. The teacher's only role in a situation like the individual and collective modes of EEG is that of facilitator and, once the initial basic instructions have been given to the students about the usage of the electronic gadget, there must be a free communication flow between the students so that learning takes place both at the individual and collective levels as conceptualized by TMST. When the members of the team acclimatize with the entire group, the transactive memory at a team level enables them to identify those students who have specific skills sets for problem-solving and who can help to make the concepts related the topic being studied more comprehensive. Argote et al. (2003) found that the transactive memory system can enhance creativity, retention, and the transfer of knowledge. Many researchers have found that transactive memory system development has a positive impact on the performance of the team members in terms of knowledge acquisition (Hollingshead, 2000; Kanawattanachai and Y. Yoo, 2007 and Zhang et al., 2007). Thus, it is imperative that the environment created by teachers during the EEG-based individual and collective mode of learning plays a vital role in its success. The implication is that it is not only the students' efforts to learn through the EEG-based individual and collective modes of learning that improves student performance, but also the confidence of teachers regarding the success of EEG and, accordingly, its facilitation of free communication between students both inside and outside the classroom.

This ultimately leads to the 'systems thinking' concept, according to which the learning process has an input and output and the process is a continuous knowledge assimilation process using EEG or any other means and the output could be the academic performance of the students (Lewis et al., 2005). Anderson and Lewis (2014) opine that there is lack of empirical evidence for these theoretical findings and further research is essential to support the theory. They adopted a modelling and simulation approach to support the theory to study the reinforcing and interacting effects of ICL. The conclusion of the study is that disruptive technologies which can support ICL can have a significant impact on learners' performance by enhancing student engagement.

## 4.4. Individual and Collective Electronic Games and Gender Difference

The first point to be considered when studying the influence of gender difference is the criteria for measuring student performance in terms of educational outcome achievement. This is because the effectiveness of the study on the influence of gender difference is as good as the criterion used for the measurement. For instance, Nowell and Hedges (1998) used national tests as the reference, Anastasi (1988) the Scholastic Aptitude Test, Kuncel et al. (2001) the Graduate Record Examination, Kebritchi et al., (2010) school-district benchmark exams, and Miller and Robertson (2011) the self-perception questionnaire. So, there are no common grounds to relate the outcome of one study with the other. Moreover, the reliability and validity of the questionnaire used are always questionable. The methods used to evaluate the student achievement measurement also varied across the studies. One group of researchers has used qualitative methods, e.g. Marković et al. (2007) and Salen (2008), another group has used quantitative methods e.g., Huizenga et al. (2009), Delacruz (2011), Miller and Robertson (2011), and yet another group has used mixed methods, e.g. Fengfeng (2008) and Kebritchiet et al. (2010). Again, when the methods used in the analysis are dissimilar, comparisons will be impossible but, nevertheless, all of these studies have contributed to the student achievement comparisons under different circumstances.

Most of the meta-analyses conducted on diversified subjects, such as mathematics, physics, science, and reading achievement, are based on the performance of students in tests measuring cognitive abilities or national test scores (Voyer & Voter, 2014). These measurements are based on the class performance of the students. Voyer and Voter (2014) observed that female students will usually have an advantage when class tests are the reference but that, later in their career, this advantage in academic achievement is not demonstrated in the form of either career success or lifelong learning.

The effort to identify the true measure of academic achievement has always been a challenge and early researchers based it on actual school performance (e.g. Pomerantz et al., 2002). There has been a very healthy debate on the fallacy associated with considering school performance alone as the basis for the influence of gender difference on student performance, as this measures only the social context of learning (Wentzel, 1991) and standardized tests measure only one performance by students (Kenney-Benson et al., 2006). So, there is first a need to narrow down the focus to a holistic measure of student performance, which can be used as the basis for comparing student performance based on gender. The age of the students who are selected for a gender-based comparison of student performance is another factor to consider. According to Voyer and Voyer (2014), it is important to determine the level at which student performance is being measured, as this may induce variance based on whether the student being evaluated for comparison is in preschool, elementary school, high school or college. So, age can be both a 'continuous variable' and/or a 'categorical variable'. Some studies have considered age to be a categorical variable and variance has been observed based on whether the student is in preschool, elementary school, high school or college (Lindberg et al., 2010). It was observed that, in the study undertaken by Lindberg et al. (2010), the male students' advantage in the tests compared to that of the female students increased with age, reaching a peak in high school and declining thereafter. In a study conducted by Pomerantz et al. (2002), a female advantage was found in elementary school, while Mickelson and Greene (2006) detected one in middle school, McCornack and McLeod (1988) one in high school, and Sullivan-Ham (2010) on at university level. It was interesting to note that Sulaiman and Mohezar (2006) observed no gender difference.

Morris, in the 1950s, found a gender difference in psychic and social differences in terms of education outcomes achievement, which has since become an active area of research (Dayıoglu & Türüt-Aık, 2004). The influence of gender difference on cognitive ability has its roots in the debate on biological versus social determinism. According to the biological perspective, the influence of gender on the cognitive performance of the students is mainly dependent on biological factors like brain structure and disregards the influence of social factors. A group of researchers (Lynn, 1998, Allik et al., 1999 and Colom & Lynn, 2004) claim that, as the average brain size of males is larger than that of females, they are expected to have a higher Intelligent Quotient and hence better educational performance but this theory faced early opposition, claiming that brain size and intelligence are independent of each other (Mackintosh, 1998).

Studies on the male and female brains have found that there is subtle difference between men and women's maths and verbal abilities. Only two gender differences in the specific areas of spatial and verbal ability, three-dimensional mental rotation (favouring men), and speech production (favouring women) have been observed (Linver et al., 2002). Other research has shown that male students somehow get higher exposure to preparing for the subject and naturally perform better. Jacobs et al. (2002) claim that academic achievement is based on the self-concept of the students, which is independent of gender difference and thus there can be no differential performance between males and females. The research on the influence of gender on academic performance is inconclusive.

In the achievement multiple-choice tests, the female students outperformed the males on science-based subjects (Murphy, 1982 and Johnson, 1987). In direct contrast, Kimball (1989) compared academic performance based on gender difference in terms of classroom grades and found that female students outperformed male students in math classes. Hanna (1986) argued that male students were willing to take more risks by their very nature so their guessing ability would be naturally higher, whereas the female students might end up with an 'I don't know' kind of attitude. Erickson and Erickson (1984) observed that male students have a natural ability to do better on knowledge related to topics based on experience. Wilberg and Lynn (1999) arrived at a similar conclusion for history tests and the reason for better performance has been attributed to working more conscientiously and having a stronger work ethic and better language ability, including essay writing skills, vocabulary and word fluency, than males. Stage and Kloosterman (1995) compared male and female students' academic performance on high cognitive level tasks at high school level and found that such differences appear to be declining. Young and Fisler (2000) compared the mathematics scores of high school seniors and found that the males scored higher than the females, but the difference was also attributed to the difference in the parents' socio-economic status, since the males were from a higher socioeconomic class and better educational background. In a recent study conducted with reference to gender difference regarding interest in Science, Technology, Engineering, and Mathematics, credits earnt and academic achievement, it was found that the gender-based difference was significant (Laird et al., 2009; Nord et al. 2011; and Cunningham et al., 2015). The same study revealed that male students had more interest in mathematics and science. In terms of liking the subject, more male students that female ones preferred mathematics. It was interesting to note that the female students displayed better academic performance in terms of grades in Algebra, Calculus, Advanced Biology, Chemistry and Health Science, whereas the male students performed better in Physics, Engineering, Science, and Computer/Information Science. However, the studies also show that the difference in the performance of the students with respect to gender is continuously reducing or even gone (Lindberg et al. 2010).

Another group of researchers considered course taking behaviour, classroom experience, and cognitive processing with regard to male and female students' respective academic performance (Byrnes et al., 1997; Young and Fisler, 2000), while other researchers argue that academic achievement tests and their administration favour male students (Bridgeman and Wendler, 1991).

A lot of research is in progress to investigate the gender influence of electronic games on learning. Again, as with the influence on electronic games on learning, the research on gender difference is also inconclusive, but the parameters chosen for comparison by these researchers and the age group on which the research is conducted also differ. In the study undertaken by Young and Upitis (1999), a gender difference was observed with respect to the involvement of the students with computer games. Agosto (2004) found that the electronic mode of learning was not related to any gender influence and that both male and female students showed the same enthusiasm towards computer games. However, Agosto also observed that boys not only played electronic games more frequently than girls, but also discussed the games more with their friends than the girls, even though both genders were equally encouraged by their teachers. In a study conducted by Kinzie and Joseph (2008), it was found that male students played electronic games far more than female students and that all students preferred to play using characters of their own gender. They also found that boys preferred active, strategic electronic games, whereas girls preferred creative, explorative games. Hartmann and Klimmt (2006) undertook a similar study and found that the boys were attracted to the competitive aspects of electronic games whereas the girls were attracted towards the meaningful social interactions.

Martin et al. (1999) found that, in mathematics, the male students performed far better than the female students across countries and Zhu (2007) reported that, in physics also, male students performed better. However, these research studies cannot be considered to be the generic ones to prove the point. Pollock et al. (2007) found that, in an introductory physics course taught via interactive engagement instruction, male students outperformed female students on conceptual learning. In a large-scale study conducted by Docktor and Heller (2008) involving students taught through collaborative problem-solving on an introductory physics courses, it was found that the males significantly outperformed the females on a pre-test.

A comparison between the genders has been undertaken with many different references, as mentioned before, but unification seems to be very difficult, or in other words it is difficult to reach a generalizable conclusion. Further, the research is inconclusive with reference to the influence of gender on academic achievement as many studies exist which are both for and against the issue. In addition to the specific cases discussed previously, a large number of researchers have found that there is a significant difference between the academic achievement of the students based on their gender e.g. Boldt (2000), Alnabhan, Al-Zegoul and Harwell (2001), Ismail and Othman (2006), Blackman et al. (2007), Demirbas and Demirkan

(2007), Dewaele (2007), Frenzel et al. (2007), King and Joshi (2008), Lehre et al. (2009), Goodman and Cirka (2009), Grave (2011) and Mullola et al. (2011). In direct contrast to this, another group of researchers has found that there is no significant gender-based difference in the educational achievement of the students e.g. Alfan and Othman (2005), Bursik and Martin (2006), Anderson (2006), Adams and Laursen (2007), Annor (2010), Hogan et al. (2010), Cogan (2010), Chen and Pajares (2010), Ari et al. (2010), Jones (2010), Kokkelenberg and Sinha (2010), Balsa et al. (2011), Calafiore and Damianov (2011) and Véronneau and Dishion (2011).

A lot of research is in progress to investigate the gender influence of EG on learning when learning takes place on individual and collective mode. Again, as in case of the influence of electronic games on learning, the research on the influence of gender on student academic achievement is also inconclusive but the parameters chosen for comparison by these researchers and the age group on which the research is conducted are also different. In the study undertaken by Young and Upitis (1999), gender difference was observed with respect to the involvement of the students with computer games. Agosto (2004) found that electronic mode of learning had no gender influence and both male and female students showed the degree of enthusiasm towards computer games. However, Agosto also observed that boys not only played the electronic games more frequently  the girls, but also discussed them more with their friends than the girls, even though both genders were equally encouraged by the teachers. In a study conducted by Kinzie and Joseph (2008), male students played electronic games much more than female students and the students preferred to play with characters of their own gender. They also found that boys preferred active, strategic electronic games, whereas girls preferred creative, explorative games. Hartmann and Klimmt (2006) undertook a similar study and found that boys were attracted towards the competitive aspects of the electronic games whereas the girls were attracted towards the meaningful social interactions.

The influence of gender difference on the ‘cognitive gain’ when the students learn through electronic games has also been an area of active research interest. Vogel et al. (2006), through their meta-analysis of several empirical studies, concluded that there was a significant cognitive gain in comparison with the traditional method of teaching without electronic games. Annetta et al. (2009), through their study of learning science using electronic games, found no significant change in the cognitive domain of the students in terms of gender difference. Ke and Grabowski (2007) applied the design of experiments and studied the main and interaction effects with the change in cognitive domain as the dependent variables. They found that neither gender difference as the main effect nor the interaction effects between gender and computer games had any significant effect in terms of mathematics achievement of 5$^{th}$ grade students. Papastergiou (2009) also observed no significant influence of gender difference on the cognitive domain in terms of the science achievement of high school students. In direct contrast to these studies, Kim and Chang (2010), through their empirical study, found a significant influence of gender difference on the cognitive domain of the students. They also argue that all of these studies have limitations in terms of sample size and generalization and that more research is required in this direction. It is important to study if gender difference has a significant influence on learning using EEG, and if so, gender-specific measures are required, so that students of both genders may benefit from the use of the technology.

Among the various studies which have been discussed, the most interesting is the meta-analysis of the available literature conducted by Voyer and Voyer (2014). This research was based on the multi-level approach to meta-analysis, and considered 502 effect sizes. The purpose of the study was to explore gender differences in the scholastic achievement of students as measured by teacher-assigned school marks, which form the basis for most of the comparisons i.e. on-going teacher marking, not end of term tests. The meta-analysis considered the influence of gender difference with respect to courses on language studies, maths, and science. The meta-analysis included gender difference studies at the elementary, junior/middle, high school, and university levels (both undergraduate and post-graduate). The meta-analysis resulted in some key findings which are quite relevant to the present research. First of all, this research attempts to find the influence of gender difference on student achievement and found a female advantage in school marks as observed through the common findings of the literature studied under the meta-analysis with specific reference to language studies, maths, and science. This study contradicts the general notion found in earlier studies that female students excel in language studies whereas male students excel in maths and science, but subscribes to the general conclusion that female students perform better in schooling in a global perspective. The study acknowledges the influence of socio-cultural factors which may influence student performance but have not been considered. The study also considers the perspective of the expectancy-value model. According to this theory, if a person has low expectancy of success and sees little future value in a specific course, that student is less likely to work hard on that course and so will naturally achieve lower marks (Steinmayr & Spinath, 2008). So, it is not mental ability alone that prevents a student from demonstrating academic achievement, but the perception of the usefulness of the course also plays an important role in students' academic performance, as inferred from the study. Nevertheless, it remains inconclusive with respect to the quantification of gender difference and suggests that further investigation of this is required. The observation in this study was that the female advantage was the greatest for language-based courses and the least for maths. Thus, further research on the influence of gender difference on student achievement is required, particularly empirical research, so that a concrete decision can be made and accordingly theories may be built to explain the reasons for this influence, if any.

## 4.5. Conclusions

The literature indicates that there are many different conceptual orientations in individual and collective mode of learning ICL. A group of researchers has attributed ICL as exerting a strong influence on learners' IKA. This concept is grounded on the theory that practice-based repetition holds the key to learning. In the context of individual learning, students must experiment to find the best way to accomplish tasks by themselves individually while, in collective learning, there is scope for ideas sharing and individuals can compare their task performance with others and optimize it. Sense-making and reflective dialogue also plays an important role in ICL. Learning is either the acceptance of something totally new or altering the earlier perception about things or concepts. So, what is learnt must make some sense to the learners and they should be able to relate it to their experience. NU is another aspect of ICL which is very powerful in sharing ideas. Researchers have identified that knowledge transfer and knowledge diffusion occur during NU which actually leads to knowledge generation.

Further, there are also social issues linked to NU which provide students with opportunities to sharpen their soft skills as they learn.

Researchers have also defined the LOL under ICL which can be either intertwined or participation-based. This concept has clearly identified the LOLs (individual, team, and class) and four processes which interact at these three levels i.e., intuiting, interpreting, integrating, and institutionalizing. The individual and human development concept is part of the humanist philosophy according to which, by their very nature, human minds are curious and only require a medium with which to interact so that the knowledge is updated. Treating students as individuals in the community, which is another concept of ICL, brings out the concept in which learning is portrayed as the effect of the social, cultural, and cognitive ability of the individual. The communities of practice concept propagates that learning takes place in the form of interaction with the community which has a common interest. The co-participation and co-emergence concept attempts to explain ICL as the involvement of students, leading to the emergence of a new set of knowledge, attitude and skills.

From the literature it is possible to identify four perspectives in the study of the process of learning (behaviourism, cognitivism, pragmatism and social constructivism). The theory of behaviourism by Skinner and Watson proposed that the behaviour of the learner can be predicted and controlled through the learning environment. Cognitivism theorized the belief of students and teachers about student performance and explained how these beliefs influence the student-teacher relationship. Pragmatism referred to the production of a particular behaviour response by transforming what is known into action. Social Constructivism theory propagates that learning is a search for meaning and students' comprehend at different stages of learning was investigated according to this theory. These theories form the basis for the ICL that takes place through EEG in this research. While each of these theories contributes to the learning in its own way, the focus of this research is the impact of EEG usage in the ICL modes.

Gender difference with regard to learning mathematics using technology has also been an area of interest to many researchers in the context of ICL. Researchers do differ in their outcomes and, while some agree that there is a gender influence on learning using technology (Kinzie &

Joseph, 2008; Hartmann & Klimmt, 2006; Upitis, 1999), another group of researchers have found that gender makes no difference in this regard (Annetta, et al., 2009; Papastergiou, 2009; Ke and Grabowski, 2007; Agosto, 2004). So, the study of the significance of the influence of gender on learning using technology is inconclusive and the literature review has identified a clear research gap which needs to be filled.

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# CHAPTER 5

# Overview of Methods

## 5.1. Introduction

This chapter provides a detailed explanation of the various methods and tools used in this research. The reasons for the choice of a particular set of methods have been discussed and the activities involved in both the qualitative and quantitative components of the research have been listed. The experimental design for the hypothesis testing has been depicted appropriately and explained, as has the sampling method. The treatment methods employed in the two experimental groups, the pilot testing of the questionnaire as well as the reliability and validity tests, and the data analysis of both the statistics and inferential statistics have all been explained.

## 5.2. The Research Methods and Tools

Even the most complex things associated with learning can be explained through relatively simple fundamental processes by adopting the reductionist approach (Jones, and Richard, 2013), which is largely a causality-based approach. To arrive at a conclusion regarding the relationship between the learning methods and learning achievement, supporting data are required. Thus, empirical data collection is necessitated. The research relies on the deterministic approach, as learning is fundamentally a social phenomenon and its determinants include a varied succession of life events (Bandura, 1989). These determinants could include age-graded social influences, biological conditions, and the physical environment. This research considers these governing philosophies in the process of establishing relationships between the variables of research interest.

To meet the aims of the research, the study attempts to investigate the influence of individual and collective EEG on academic achievement and permanency of learning, the gender influence on the learning and permanency of learning through individual and collective EEG, and the perspectives of teachers on individual and collective EEG. To accomplish this, the research deliberately adopts a mixed methods approach which combines both qualitative and quantitative techniques, and thus exploits the strengths of both approaches.

Qualitative research is necessary because the research has to take place in a natural setting (field focused) and the researcher is the key to collecting some of information. Multiple data sources are necessary in the form of both words and images. Further to this, the analysis demands observations during the interaction between the groups involved in the study i.e. the teachers and students. The perspectives and subjective views of the participants are required. An interpretative inquiry into the situation was also used in order to understand the students and teachers' experiences of games. On the other hand, the qualitative observations need to be supported by quantitative evidence to elucidate the arguments which arise in the research. Descriptive outcomes in the form of correlation as well as inferential statistics in the form of cause-and-effect relationship testing were also necessary in this research. Thus, a mixed methods approach was chosen for this research.

The qualitative component of this research adopts a Grounded Theory approach loosely, in the sense of denoting that the qualitative data collected allowed participants to give their views, rather than simply to test the researcher's hypothesis concerning their views. It is chosen over what tends to be called phenomenology because this would merely end up giving meaning to the observed phenomenon experienced by a number of participants, but in this research there is a need to go beyond description and aim to generate a theory or an analytical schema of a process drawn from the use of individual or collective EEG. The participants in these two forms of learning would undergo an experience and that should lead to a certain conclusion regarding the influence it can create on learning. The theory needs to be generated or grounded in the data collected from the participants (Creswell, 2004). By definition, grounded theory is itself a qualitative research design in which the inquirer generates a general explanation (a theory) of a process, action, or interaction shaped by the views of a large number of participants (Strauss and Corbin, 1998).

The quantitative research adopts the approach of experimental research because the research demands the testing of the hypothesis in the form of seeking causation where two different methods of learning are to be comparatively analysed on a pre- and post-test basis. The two methods of teaching become the independent variables, which influence the amount of learning which takes place under the experimental conditions and the learning progress becomes the dependent variable. Experimental research is chosen specifically because it enables the systematic process of selecting the problem, formulating the hypotheses and deducing their consequences, and constructing an experimental design that represents the elements, conditions, and relations of the consequences. An evidence-based approach to research, which forms the basis of this research, is one where the best evidence with practitioner experience and other sources is used to test a hypothesis (Dale, 2005). The evidence gathered by the researcher and the revelation of the hypothesis is combined to arrive at a conclusion. The activities involved in qualitative and quantitative research (Experimental Research) are listed in Table 5.1.

Table 5.1: Activities involved in the Qualitative and Quantitative Research

| **Activity** | **Qualitative Research** | **Quantitative (Experimental Research)** |
|---|---|---|
| 1. Respondent selection | Students and teachers who are part of the processes in individual and collective EEG. | Students who are part of the processes in individual and collective EEG. |
| 2. Building rapport | Locating the homogeneous sample of students and teachers. | Locating the homogeneous sample of students. |
| 3. Selecting a purposeful sampling strategy | Finding a sample of the required size. | Finding a sample of the required size. |
| 4. Deciding on the forms of data | Semi-structured interviews with two teachers (Primary data) | Questionnaire survey with 74 students and 124 teachers (Primary data). |
| 5. Recording of | Questionnaire Survey (Appendix | Self-administered questionnaire |

| | | |
|---|---|---|
| data/information | 1) and Semi-structured Interview protocol (Appendix 2). | (Appendix 1). |
| 6. Field work related activities | Arranging logistics and developing openness among respondents. | Logistics and encouraging active participation. |
| 7. Recording of data/information | Transcriptions and computer files. | Data Sheet (Appendix 3). |
| 8. Analysis of information/data | The information collected from the semi-structured interviews with two teachers will be coded and themes extracted to produce the findings. | Statistical analysis in the form of a t-test and ANOVA will be performed on the data collected through questionnaires to seek relationships. |

The tools used in the quantitative analysis take the form of software packages including MS Excel for the descriptive statistics and IBM SPSS Version 19 for the inferential statistics in the form of a t-test and Analyses of variance (ANOVA).

### 5.3. Hypothesis Testing Method

An experimental design has been used to test the hypotheses formulated in this research. More specifically, the Completely Randomized Design (CRD) has been adopted because it is the best suited design for the research problem being tackled. In this research, the effect of individual and collective EEG on the academic achievement of learners as well as the permanency of learning have to be tested, which necessitates a pre-test and post-test of the students' performance. The CRD will be the most appropriate approach in this situation, as it provides the option of employing two experimental groups independently and subjecting them to two different treatments i.e. the individual and collective mode of learning and recording the performance before and after the treatment. The independent variables will be individual learning through EEG (Treatment Group A) and collective learning through EEG (Treatment Group B) and the dependent variable in both the cases will be learning outcome attainment.

## 5.4. The Sampling Method

The sample comprises primary school children who were randomly chosen from Al-Jeel Al Jadeed School in Kuwait. The school is a privately-owned, independent co-educational day school in Hawalli, associated with the U.S. State department through the Office of Overseas Schools and formally recognized by the Kuwait Ministry of Education. The school has a primary education set-up, with 184 teachers and 850 students. This is one of the preferred schools by parents in Kuwait. Exactly 74 students from 5$^{th}$ grade primary school (aged 9 to 10 years) were randomly chosen and were divided into Experiment Group A and Experiment Group B containing 37 students each (Luci Nunes-Dore, 2001).

This school was chosen for several reasons. First, it was coeducational and, second, it used Educational Electronic Games. Finally, the location was selected for the experiment as the teachers were more enthusiastic and the students were from diverse socio-economic groups, which facilitated randomization. The sample size of 74 was chosen based on simple random sampling. Usually, a minimum sample size of 35 is required to make it large enough to be subjected to a parametric test so, in order to have 37 participants per group, the number 74 was chosen, but the important aspects are the random, unbiased selection of the sample. The experiment enabled the measurement of learning attainment under the individual and collective methods of EEG-based learning. The experiment and field plan are shown in Table 5.2 and the typical mathematical EEGs used by the students during this research are shown in Figures 5.1-5.4. The choice of EEG is based on the game rating in the Apple Store and is also the most widely used EEG.

Table 5.2: The Experiment and Field-plan Layout

| Group | Pre-test measurement | Treatment | Post-test measurement |
|---|---|---|---|
| Treatment Group A | Achievement test | EEG Individual | Achievement test |
| Treatment Group B | Achievement test | EEG Collective | Achievement test |

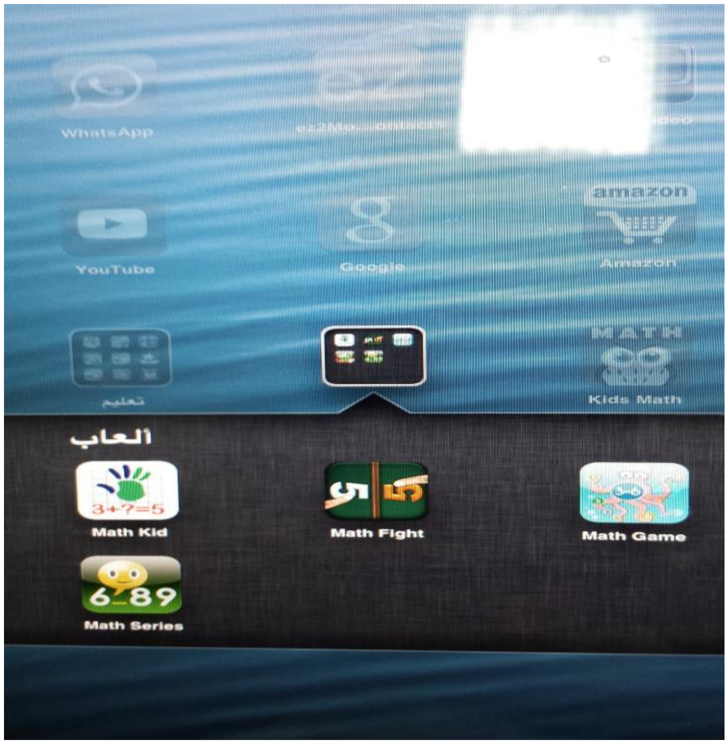



Figure 5.1: Snapshot of EEG on iPAD


Figure 5.2: Snapshot of EEG on iPAD

Figure 5.3: Snapshot of creative symbols of EEG on iPAD

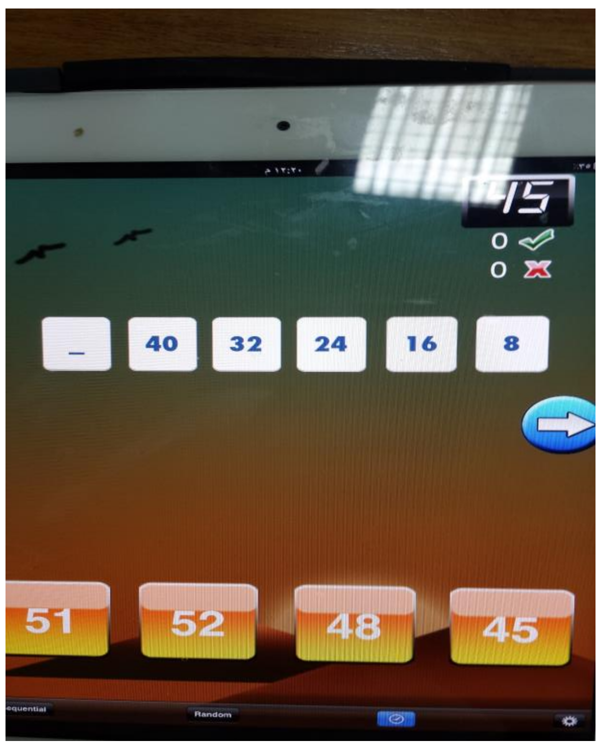



Figure 5.4: Snapshot of evaluation of EEG on iPAD

The sample size for the research was based on simple random sampling. There are 722 public schools and 521 private schools in Kuwait, with about 12,000 students studying in 5$^{th}$ grade (aged 10-11 years) (KEIR, 2013). Using the inclusion criteria of Kuwaiti Schools, Co-education, and usage of EEG in one form or the other, the Al-Jeel Aljadeed School, from Hawali, Kuwait, was chosen randomly. This school had 120 students studying in 5th grade. Even though the students were chosen randomly, the choice of location was based on geographical location, support from the Principal, and the diversity of students and so provided a better representation of the sample. Also, there are 360 teachers teaching 5th grade in the public schools. Thus, the sample size required is calculated based on the standard formula of sample size which yielded 74 students and 124 teachers (Kerlinger, 2010):

## 5.5. Method used for the Data Analysis

The analysis of data involved descriptive and inferential statistics.

**Descriptive Statistics**

The descriptive statistical parameters include: mean, standard deviation, skewness, kurtosis, frequency distribution and cross tabulation, and percentages. The mean and standard deviation provide give a broad idea about the perceptions of the teachers on the aforementioned parameters in terms of their central value and spread. The skewness and kurtosis values for the sample would indicate if normality of distribution can be assumed. The percentages make it possible to map the perceptions in terms of the agreement of the respondents with the three dimensions in the categories of ‘poor’, ‘bad’, ‘average’, ‘good’ and ‘very good’ with reference to the indicators of the dimensions being studied.

The teachers’ perceptions on the individual dimensions of Individual-collective EEG readiness were measured, and the responses to the Likert 5-point scale were rated under five distinct categories. If the response was 1, it was rated as ‘Bad’; 2 was rated ‘Poor’; 3 was rated ‘Average’; 4 was rated ‘Good’; and 5 was rated ‘Very good’, based on the total responses received for the categories on the questionnaire for the individual constructs. The scores for the ‘Bad’ and ‘Poor’ category were combined into a ‘Disagree’ category while those for ‘Good’ and ‘Very Good’ were combined into an ‘Agree’ category, and the remainder were categorized under the ‘Neutral’ category. Based on the total number of responses for each category, the percentages were calculated for each category to obtain the overall perception of each of the individual items on the questionnaire. These perceptions were presented in the form of tables and histograms to describe the data.

**Methods used in Inferential Statistics**

Inferential statistics would mainly be used for the causal analysis to test the following hypothesis that was developed based on the research question which needed to be addressed. The response to the questionnaire with respect to the three dimensions of EEG using the individual and collective mode will be separated, based on the teacher background characteristics of the teachers and subjected to ANOVA.

## 5.6. Conclusions

In this chapter, an overview of the methods used in this research has been presented. It was concluded that the reductionist approach would be most appropriate for establishing the causation between the research parameters of interest. The mixed method approach with a combination of the qualitative method, grounded theory approach and quantitative methods with an empirical approach was considered to be appropriate for this research, based on the nature of the research parameters under investigation and the literature support available from similar research studies. It was concluded that a completely randomized design with replication and two experimental groups was most appropriate for the hypothesis testing. For both experimental groups, a pre-test and post-test was designed based on the achievement test performance of the students in individual and collective EEG usage. The standard sample size calculation was used to estimate the sample size. A thorough discussion of the data analysis procedure resulted in the selection of t-tests and ANOVA as the two techniques for testing the hypotheses. T-tests and ANOVA were used in preference to non-parametric tests such as Chi Square, as these were considered to be more powerful and robust in identifying significant differences. The probability level of significance testing adopted was $P < 0.05$. Following an ANOVA, a sub-group comparison test was employed. These are reported for completeness, even in cases where the ANOVA itself as not significant. Through a comparative analysis of the schedule, a telephone, mail/fax, email/online survey, and self-administered questionnaire, it was concluded that a self-administered questionnaire was the most appropriate method for collecting the primary data from the teachers.

# CHAPTER 6

# Methods and Research Questions

## 6.1. Introduction

At the outset, the aim and rationale of the research is presented to ensure that the methods used are appropriate and provide answers to the research questions. Seven research questions have been framed to meet the aim of the research. The research questions will be answered mainly through the results obtained through the quantitative analysis and also through a qualitative analysis of the primary data. The quantitative analysis is through descriptive and inferential statistics. The hypothesis testing and the methods used for the analysis have been explained in this chapter. The reason for choosing a particular method has also been highlighted.

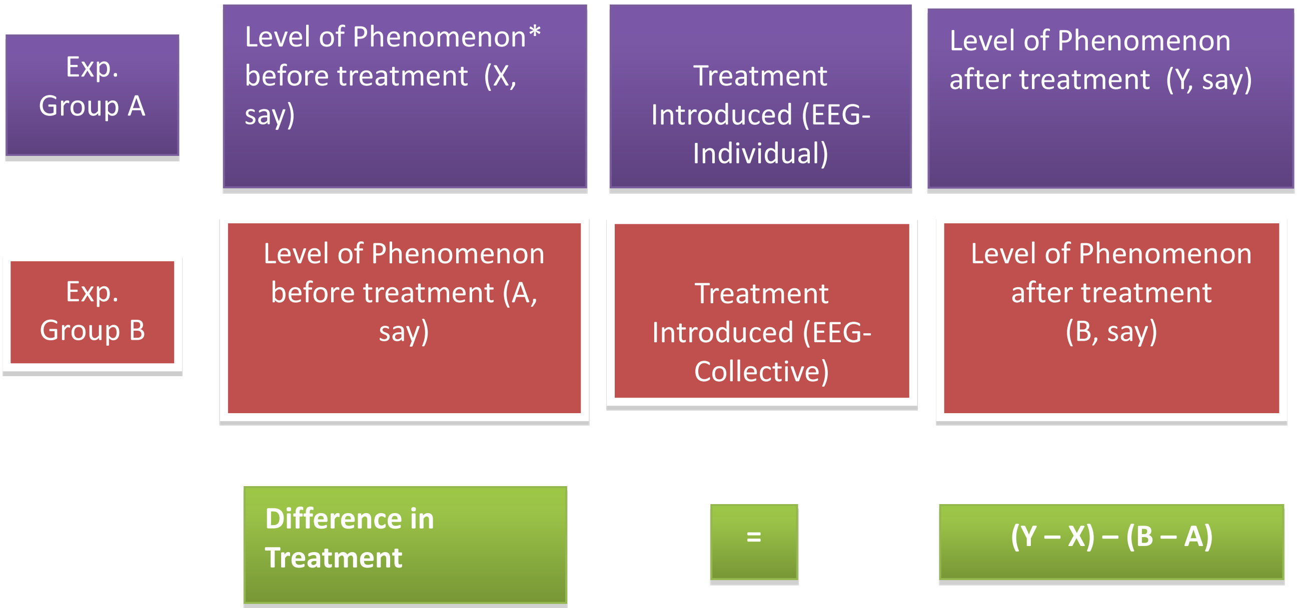
## 6.2. Research Questions and Hypotheses

RQ1: What is the effect of individual and collective EEG on the academic achievement of learner while studying mathematics in primary school?

As mentioned earlier, research questions 1 and 2 represent the first stage in the data analysis prior to identifying whether the two EEG conditions (individual versus collective) had a differential effect. This research question demands to be addressed in quantitative terms. The testing of the hypothesis would be the most appropriate method in such a case. This research question can be hypothesized as follows.

$H_{1o}$: There is no statistically significant difference at the $p<0.05$ level between the averages of the sample members (individual and collective) in the pre- and post-application of the achievement test in mathematics.

The Experimental Design is required to test this hypothesis (figure 6.1).




*Children's level of mathematics learning

Independent Variable: Experiment Group A – Individual learning through EEG.

Experiment Group B – Collective learning through EEG.

Dependent Variable: Academic Achievement of the learner.

Figure 6.1: Experimental Design

As the research tests causality, an experimental design is the obvious choice. The randomly chosen group of students were divided into two groups (Treatment Groups A and B). The level of the phenomenon was measured before treatment (pre-test of achievement) and then the treatment was introduced and the level of phenomenon was measured after the treatment (post-test of achievement). The two treatments for groups A and B were learning through EEG on an Individual basis and a collective basis, respectively. The effect of treatment was measured in terms of the difference in the treatment, as shown in Figure 6.1.

A non-experimental hypothesis testing type of research design was chosen in this research. The research becomes non-experimental because the researcher does not have the control to manipulate the independent variable (Learning through EEG in the individual and collective modes). This is because, even after explaining the learning process completely to the students, their participation is not fully under the researcher's control, particularly the attitudinal factors of the students which include the cognitive, affective, and action component (intention). However, the researcher can observe the phenomenon and record the changes in academic achievement as created by the two methods of learning through EEG under comparison. The EEG used in this exercise included Magic-Math, Math-Kid and Kid-Math on iPhone. Thus, a non-experimental, completely randomized hypothesis testing research design was considered ideal for this.

In this type of research design, a confounded relationship is possible due to the intervention of the extraneous variables. The knowledge of the facilitator about individual/collective learning, the setting of the school, the mental state of the students at the time of learning, the background of the students, the topics chosen, the time of learning, etc., could all be extraneous influences which may affect the study results. However, to some extent, the possible variance caused by extraneous influences is minimized, as both groups are likely to be influenced by these extraneous variables equally and be nullified, so that the influence of the independent variable alone could have the maximum effect on educational outcome attainment.

## 6.3. The Procedure for the Data Collection

The following steps were followed:

1. The teacher's role was to provide the students with an explanation of the purpose of the entire exercise in a classroom in the presence of the facilitators. The teacher provided the basic instructions about operating on the EEG to both the treatment groups. However, the students in the treatment group A were asked to work individually and treatment B in predetermined groups. The EEG chosen was iPad based on the game rating in the Apple Store. The snap shot of the games has been shown in section 5.4. No much instruction was necessary as the EEG was user friendly to a great extent.
2. They were informed by the teachers that they need to undergo three stages of operations. First, take a pre-test on mathematics to test their existing knowledge (30 minutes' duration). Second, they were taught using EEG in the individual or collective mode based on

their grouping (45 minutes' duration). The intervention lasted for three weeks and had three lessons. Third, they take a post-test to establish about the knowledge acquired through EEG (30 minutes' duration). In addition, they were told that they would have to take a test again to assess the permanency of their learning a week later (30 minutes' duration).

3. An opportunity was given to the students and teacher in the class to ask questions, if any. One student asked if the time allowed for answering the questions could be extended slightly. In a polite manner, it was conveyed that, due to the nature of the test, this was impossible. Another student asked whether the answers to the questions would be contained in the EEG. It was explained that the numerical aspect could change but that the method of solving would remain the same. The teacher had no questions as there had been a discussion before the session. She was a regular user of EEG and was knowledgeable about the system.
4. The students were also told that if they felt that the learning or the test strained them at any stage, they had the right to leave the hall immediately, but they were very curious and none of them left. In fact, they were inquisitive about their performance during the pre-test and post-test. Their participation in learning through EEG was excellent.
5. The students were sent to the two pre-allotted classrooms where they were to undergo EEG-based learning in the individual and collective modes.

***Treatment Group A***

1. The pre-test questions were given out and the students were asked to answer the questions. The time allotted for the test was 30 minutes (Appendix 4).
2. The answer scripts were collected back after the stipulated time (Appendix 5).
3. The instructions were given to participate individually through the EEG. The pre-selected exercises were given to the students with appropriate instructions and the EEG gadgets were distributed. The time duration for the learning through individual learning, which is learning on an individual basis using EEG as explained earlier, was fixed at 45 minutes. The

teacher was available to facilitate learning. At the end of the allotted learning time, the individual learning through EEG was terminated and the gaming gadgets were collected.

4. A post-test of achievement was given to the students and the answer scripts were collected after 30 minutes (Appendix 4).

***Treatment Group B***

The same steps were followed except that the learning was though the use of EEG on a collective basis. The students were divided into five groups of six and one group of seven students (n = 74 split into two). Generally while learning in collective form the group size can vary from four to eight depending on several conditions including the topic being studied, the age group of participants, background of students, etc. But six is considered ideal number of grouping as larger number may be over crowded with a member not getting a chance to communicate and smaller number may not limit the ideas being generated and opportunity to gather multiple view points. The pre-test and post-test were the same, with the same set of question papers. The question paper used for the pre-test and post-test is given in Appendix-4.

## 6.4. The Methods used in the Analysis

Statistical Analysis is most appropriate to use in this research as it involves hypothesis testing. The t-test was chosen due to the following reasons:

- The population variance (or Std. dev.) is not known.
- Relatively small samples were used, where a comparison of the means is involved.
- It provides flexibility regarding the type of sample distribution.

The statistical analysis includes the following steps:

The research seeks *posteriori* (or empirical) knowledge. So, the knowledge available will have to be systematically collected and analysed through the most appropriate data source. In this research, the empirical study makes use of statistical techniques to analyse the data collected for this purpose. This research makes use of descriptive statistics and inferential statistics.

While the former is used to describe the general pattern and nature of the data, the latter is used to draw inferences in order to arrive at specific conclusions of the study.

Descriptive statistics include tools such as the mean, standard deviation, teacher background, distribution of respondents, skewness and kurtosis, and overall perceptions of the respondents. Inferential statistics in this research include empirical study in the form of non-experimental hypothesis testing. The non-experimental hypothesis testing research involves experimentation with the independent variables that influence the dependent variables, but the researcher cannot manipulate the independent variables at will as he/she has no control over them but still the dependent variables are manipulated by the influence that takes place naturally and the researcher makes observations by collecting data in quantitative and qualitative forms. In this research, the metric in the form of a Likert 5-point scale is used to collect both the qualitative and quantitative data.

**Hypothesis Testing**

The decision criteria are based on the following steps:

1. Hypothesis:

$H_0$: μA > μB

$H_1$: μA < μB

2. Alpha level = α = .05

3. Test statistic: t statistic for a one-tail t test equality of the means.

4. Decision criterion: Reject $H_0$ and accept $H_1$ if p-value < .05

5. Conclusion: Based on the alpha value of this sample and analysis, the significance of difference between the two means was obtained. The average test score for children who learnt by individual EEG was compared with the average test scores those who learnt by collective EEG. Thus the hypothesis was tested to see whether the difference in educational attainment was more significant for one method over the other. The students working in the individual and collective modes are shown in Appendix 9.

RQ2: What is the effect of individual and collective EEG on the permanency of learning while studying mathematics in primary schools?

The Hypothesis:

$H_{2o}$: There is no statistically significant difference in the $p<0.05$ level between the averages of the sample members (two groups) in the post application on the achievement test of maintaining **permanency** of learning in mathematics while working on individual and collective EEG.

The experimental design, the sample and the process will remain the same as before except for the analysis which was undertaken on the achievement test scores after two weeks of the conduct of the experiment.

RQ3: What is the differential effect produced by individual and collective EEG on the academic achievement of the learner while studying mathematics in primary school?

$H_{3o}$: There is no statistically significant difference in the $p<0.05$ level between the averages of the sample members (two groups) in the post application regarding the difference in the achievement test of mathematics learning while working on individual and collective EEG.

The experimental design, sample and process will remain the same as in RQ1, except for the analysis of the difference between the means of the differential scores for the individual and collective modes of EEG-based learning. An independent variable t-test is recommended strongly to compare the two independent samples which are the differences produced during the pre-test and post-test conditions

RQ4: What is the differential effect of individual and collective EEG on the permanency of academic achievement of the learner while studying mathematics in primary school?

The experimental design, sample and process will remain the same as in RQ1, except for the analysis of the difference between the means of the differential scores for the individual and collective modes of EEG-based learning with specific regard to permanency of learning. An independent variable t-test is recommended strongly to compare the two independent samples which are the differences produced during the pre-test and post-test when the special emphasis was the conditions under which the permanency of the sample data are maintained and recorded.

RQ5: What is the effect of individual and collective EEG on the academic achievement of learner gender-wise while studying mathematics in primary schools?

$H_{3o}$: There is no statistically significant difference in the $p<0.05$ level between the averages of the sample members (individual and collective) based on gender in the post application of the achievement test in mathematics while working on individual and collective EEG.

The experimental design, sample and process will remain the same as before except for the analysis, which was undertaken as follows.

1. The test scores of the male and female students for EEG using the individual and collective modes were separated.
2. The following comparisons arise:

| | Individual EEG | Collective EEG |
|---|---|---|
| Male | Student performance (dependent variable) | Student performance (dependent variable) |
| Female | Student performance (dependent variable) | Student performance (dependent variable) |

3. An independent sample t-test was conducted to check if there was an influence of gender on performance.
4. Statistical procedure:
   i. Hypotheses:

$H_0$: μ1 = μ2 = μ3 = μ4 (There is no gender difference based on each individual and collective mode of EEG learning)

$H_1$: Not all four means are equal (There is a difference based on gender for each individual and collective mode of EEG learning)

ii. $\alpha = .05$

iii. Test statistic: F-statistic

iv. Decision criteria: Reject $H_0$ and accept $H_1$ if p-value < .05

v. Calculation: p-value =

vi. Conclusion: Based on the results of this sample and analysis, the null hypothesis was accepted or rejected.

5. Based on the mean scores, the performance of the male and female students was compared. This should also reveal which one of the two methods (individual or collective) would be preferred gender-wise based on academic achievement.

RQ6: What is the effect of individual and collective EEG on the permanency of learning gender-wise while studying mathematics in primary schools?

The Hypothesis:

$H_{4o}$: There is no statistically significant difference in the p<0.05 level between the averages of the sample members (individual and collective) based on gender in the post application on the achievement test with regard to maintaining permanency of learning in mathematics while working on individual and collective EEG.

**Experimentation**

The experimental design, sample and process remained the same as in RQ3, except for the analysis of the achievement test scores two weeks after the experiment was conducted.

RQ7: What are the teachers' perspectives on individual and collective EEG based learning while studying mathematics in primary schools? Do they vary with the teacher background?

This research question emerged through the review of earlier studies. According to Can and Cagiltay, (2006) only a limited number of scholarly articles mention the educators' views about the use of computer games in education and it is unwise to integrate EEG unless a thorough study of its impact on learning is undertaken. Teachers play an important role in the success of EEG as its usage as an educational tool may fail due to several reasons including: a lack of EEG usage awareness (Whetstone and Carr-Chellman, 2001 and Smaldino et al., 2005), a fear of losing authority (Grabe and Grabe, 1998), system-related issues (Lunenburg and Ornstein, 1996), and a lack of assessment skills and negative poor teacher attitudes regarding EEG (Prensky, 2001). A group of researchers including Rieber (1996) Prensky (2001) and Subrahmanyam et al. (2001) have stated that all EEGs cannot be considered as valuable, positive, or useful for educational purposes. In terms of the academic achievement of students through EEG, some researchers have found it to be beneficial (Durkin and Barber, 2002 and Subrahmanyam et al., 2001) while others have found that it does not enhance academic achievement (Anderson and Dill, 2000; Colwell and Payne, 2000; Prensky, 2001 and Anderson and Bushman, 2002). Kapralos et al. (2011) assessed the perceptions of learners as well as educators of the simulation-based learning environment and concluded that the perceptions of the teachers play an important role and that the success of EEG depends upon their ability to link them to the course material. In some cases, it was found that teachers were quite enthusiastic about the use of EEG, but suffered from an adoption barrier for several reasons (Brennan, 2010). According to Lawless and Pellegrino (2007) school teachers' ability to integrate technology into the teaching/learning process plays a vital role in the success or failure of EEG in schools. So, despite the fact that EEG is supposed to be student-centric in the learning approach, it is important to understand the teachers' perceptions about its usage in education because its success or failure lies partly in the hands of the teachers who act as the facilitators of learning.

The second part of the questionnaire survey demanded the collection of qualitative data about the perceptions of the teachers on EEG usage. To elicit the information from the teachers, the questionnaire contained the following qualitative questions:

1. What are your specific suggestions for improving the individual learning of students?
2. What are your specific suggestions for improving the collective learning of students?
3. Do you find EEG useful in teaching-learning? If so why? If not, why not?
4. How do you think EEG has contributed specifically to the learning of Mathematics?

In addition to the above research questions, a semi-structured interview was conducted with two teachers (for the protocol, see Appendix 2). The entire semi-structured interview was recorded and the key points were noted and analysed to arrive at a conclusion about teacher perceptions of EEG.

A descriptive study was undertaken to identify the teachers' perceptions on the following dimensions related to usage of EEG in the individual and collective modes and the variations between these perceptions based on teacher background:

1. Individual-collective EEG readiness.
2. Usefulness of EEG tools.
3. Impact of EEG Methods on Learner Achievement.

A Questionnaire survey method was employed to collect the data through a self-administered Likert 5-point type questionnaire. The sequential steps involved in the questionnaire design were as follows:

| **Steps** | **Process** |
|---|---|
| 1. | Convert the research objective to information need |
| 2. | The method of administering the questionnaire |

3. Content of the questionnaire

4. Motivating the respondents to answer

5. Determining the type of questions

6. Question design criteria

7. Determining the questionnaire structure

8. Physical presentation of the questionnaire

9. Pilot testing of the questionnaire

10. Administering the questionnaire

**1. Convert the research objective to measurable items**

The research questions have been converted into measurable items which are represented on the questionnaire (Table 6.2).

Table 6.1: Conversion of Research Questions to Information

| **Research Questions** | **Variables to be Studied** | **Item on the questionnaire (primary data)** | **Population to be Studied** |
|---|---|---|---|
| RQ5 What are the teachers' perspectives on individual and collective EEG-based learning while studying mathematics in primary school? | Teacher background.<br><br>Individual-Collective EEG Readiness. | Age, gender, designation, experience, course taught, training in EEG, EEG used.<br><br>Knowledge of Computers, Parents' Skills, and Selected Electronic Game.<br><br>EEG type, Mathematics | Teachers (N = 124) |

| | | | |
|---|---|---|---|
| | Usefulness of EEG Tools<br><br>Impact of EEG methods on learner achievement. | learning skills and quizzes.<br><br>Device Learning Skill and Concept, and Teachers' Computer Skills. | |

**2. The method of administering the questionnaire**

As there are various methods for administering the questionnaire, it was necessary to assess the relative usefulness of these, and hence a comparative analysis was undertaken to compare one method over the others in order to choose the most appropriate one (Table 6.2).

Table 6.2: Relative Usefulness of the Data Collection Methods

| | **Schedule** | **Telephone** | **Mail/Fax** | **E-mail/online survey** | **Self-administered** |
|---|---|---|---|---|---|
| 1. Administrative control | High | Medium | Low | Low | High |
| 2. Sensitive issues | High | Medium | Low | Low | High |
| 3. New concept | High | Medium | Low | Low | High |
| 4. Large sample | Low | Low | Medium | High | Low |
| 5. Small sample | High | High | High | High | High |
| 6. Cost/time consumed | High | High | High | Low | Medium |

| | | | | | |
|---|---|---|---|---|---|
| 7. Question structure | Unstructured | Both | Structured | Structured | Structured |
| 8. Sampling control | High | High | Low | Medium | High |
| 9. Response rate | High | High | Low | Medium | High |
| 10. Facilitator bias | High | High | Low | Low | High |

The general features of this research are: a small sample size, better administrative control required, the non-existence of sensitive issues, the possibility of new concepts being developed, the limited time available, the need for structure, better control over the sample, a better response rate, and minimum facilitator bias. An email/online survey would have been ideal for reaching the maximum number of respondents in a short span of time; however, as the sample size was relatively small and it was easy to access the respondents, this was considered unnecessary in this research. So, a self-administered questionnaire was considered more appropriate and hence chosen.

**3. Content and length of the questionnaire**

Time was an issue, as the teachers who are the respondents to this research were preoccupied with their regular duties, as usually observed in any other questionnaire surveys. At the same time, the content of the questionnaire was intended to cover the maximum amount of information required to answer the research question under investigation. The questionnaire was designed to be well-structured and contain limited questions while at the same time covering the topic adequately. The questionnaire is given in Appendix 1.

**4. Motivating the respondents to answer**

Several measures were taken to ensure that the respondents were well-motivated to answer. The background to the research is given at the beginning and the research questions are included on the questionnaire. Care was taken to ensure that the questionnaire would involve the respondents and motivated them to respond. As the respondents are teachers, they have a natural inclination towards academic matters and the whole questionnaire is oriented towards this area. It was confirmed that the respondents had all of the information which was elicited through the questionnaire.

**5. Determining the type of questions**

The questions could be open-ended or closed-ended, and the latter type could be dichotomous, multiple-response, or scaled. In this research, the teacher background section was compiled using multiple choice questions so that the respondents could select an option easily. The main quantitative primary data were collected though Likert-type 5-point rating scale. Finally, the qualitative data through the questionnaire were collected via open-ended questions. The open-ended questions were compiled to provoke the teachers to provide descriptive answers and so produce new insights into this research area.

**6. Question design criteria**

While translating the questions into the individual items on the questionnaire, specific criteria were followed to ensure effectiveness. First of all, the questions were tested and rephrased if necessary to 'clearly specify the issue' without any diversions or redundant elements. Simple language was adopted so that the respondent would be able to answer the questions with ease without any ambiguity. During the pilot run of the questionnaire, the 'construct and content validity' was verified through discussions with some school Principals and academics with wide experience in the field. Leading questions were completely avoided, as these would generally provide the respondents with clues about which direction to choose while answering the question, which would induce bias into the answers. There were no loaded questions on the questionnaire (in terms of gender, race, nationality, etc.). The questions used are also never 'double-barreled' (i.e. they all focus on a single issue to assess).

**7. Determining the questionnaire structure**

The questionnaire is structured systematically into several parts. The first part defines the purpose of the study so that the respondent was aware of the importance of an honest, truthful response. This was followed by a declaration by the researcher that the data will be used solely for the research purpose. The next section provided the researcher's contact details so that the respondents could contact him/her if necessary. These were followed by the contact details of the respondent, which are marked 'optional'. This ensured that the confidentiality of the respondents was maintained. Following this section, the background to the study and research questions are listed. After these general sections, the first type of data i.e. the demographic data of the respondents, were collected through the optional questions. The next section collected the quantitative data in the form of a 5-point Likert scale. This section includes: individual-collective readiness, the usefulness of EEG tools, and the impact of EEG methods on learner achievement. The final section is the qualitative data in the form of open-ended questions. This section comprises: the suggestions of the respondents on improving individual and collective learning; opinion on whether the respondents really found EEG useful in teaching/learning and the specific reasons for their opinions; and the contribution of EEG to mathematics learning. The questionnaire ends with an acknowledgement of the valuable input by from the researcher. As the Principal had specifically requested, the general perceptions of the teachers about the EEG based on the survey findings were given in the form of feedback, with no mention of the respondents' details in any form.

**8. Physical presentation of the questionnaire**

The physical presentation of the questionnaire was given importance so that the respondent would pay attention and be motivated to complete the survey. Clarity and brevity were considered important and the entire questionnaire was written in a crisp, easy to read format. The font style and format was made uniform in order to ensure that the questionnaire was presented neatly.

**9. Pilot testing of the questionnaire**

A pilot run was conducted on the questionnaire which involved testing and administering it with a small sample of 21 teachers. Usually, a pilot run is performed with a small sample of five to ten participants, but as the distribution was to be studied and the reliability was to be estimated, a relatively a larger sample was chosen (20 to 30 is commonly used). These participants were specifically chosen due to their interest in the research area. The instrument used in this research was subjected to content and criterion-related validity testing.

**Content Validity:** Content validity refers to the degree to which the items in an instrument reflect the content universe to which the instrument will be generalized (Straub et al., 2004). Generally, content validity is not easy to assess, since the commonly employed evaluation of this validity is judgmental and highly subjective (Straub et al., 2004). To explore the content validity, the questionnaire was presented to two teachers and a Principal with proven experience in the area of academic research. Their views about the content of the questionnaire were obtained and the following additional questions were added to confirm that the content was adequate to obtain the data required for the research:

1. The learner is highly performing while playing mathematics – Knowledge of Computers.
2. The teacher should provide a wrong answer to help learners to work out how to rectify mistakes – EEG Type

Also, based on the inputs of the experts, a few statements were re-worded in accordance with their inputs, e.g. 'The learner comprehends learning acceptably' was rephrased into 'The learner is responding quickly to the activities in mathematics'. The content of the questionnaire was vetted through two the school Principals with expertise in this area.

**Construct Validity:** Construct validity assesses whether the scales were measuring what they were designed to measure. The questionnaire was distributed to a group of six teachers and their opinions on its ability to measure what it intends to measure were collected. These were asked to assess the comprehension, readability, and suitability of the instrument. As the responses were positive except for some minor modifications, the construct validity was ascertained.

**Practicality**: The practicality of a measuring instrument is judged in terms of economy, convenience and interpretability, as mentioned previously. This is one of the reasons for retaining a minimum of 47 questions on the questionnaire, taking care to provide maximum coverage of the study topic. 'Convenience' forms another key factor of practicality. The questionnaire was designed to be self-administrative in nature and clear guidelines were given on the instrument itself, so that there would be minimum number of queries regarding the manner of its completion. The Likert scale scoring keys were stated at the beginning and separate columns were provided for ticking the responses under each category. Interpretability of the items was given sufficient importance to ensure that each question had only one meaning, free from ambiguity.

Thus, with a fair degree of certainty, the instrument was tested for the validity to ensure that it measured what it was expected to measure.

**Normal Distribution of Data:** It is important to confirm whether the data are normally distributed so that they could be subjected to parametric tests. Skewness and Kurtosis are the two measures of normality testing of the data which were adopted in this research. The sample distribution followed the normal distribution (Skewness values ranged from -1 to +1 and Kurtosis ranged from +3 to -3) (Appendix 6).

**Reliability**: The 'stability' aspect of reliability is concerned with securing consistent results with repeated measurements of the same person with the same questionnaire. The method of determination of the degree of stability by comparing the results of repeated measurements has been adopted in this research. The most common approach for estimating the reliability of an instrument that is presented to respondents only once is the 'split-half reliability'. In this approach, the test is split into two equivalent halves and the scores of the respondents for one half of the test are correlated with those for the second half. The difficulty in this approach is determining whether the two halves are equivalent. Cronbach proposed the coefficient 'alpha' (the 'Cronbach's Alpha'), which may be considered the mean of all possible split-half coefficients. It is important to study the reliability of the data before subjecting it to further analysis. The Chronbach's Alpha is a measure of the internal consistency of the data. It estimates the proportion of variance that is systematic or consistent across a set of test scores (Cronbach, 2003). A test with 'robust' reliability would be expected to display a Cronbach's Alpha in excess of 0.9. However, values above 0.7 are usually acceptable indicators of internal consistency, as suggested in the literature (Creswell, 2004). The reliability of the questionnaire was tested on this basis of a sample size of 21 in the pilot study. For these pilot study data, the Cronbach's Alpha value is 0.8 (Table 6.3) and the data have a moderately high level of reliability.

Table 6.3: Reliability Analysis

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .825 | .835 | 47 |

**10. Administering the questionnaire**

Finally, after passing through all of the above stages, the questionnaire was self-administered to the respondents (teachers) as per the sampling plan. The questionnaires were distributed in the form of a hard copy and the completed questionnaires were collected back. Ethical permission was obtained from the Ministry of Education as per the standard procedure to collect data from the students and teachers (Appendix 7).

**RQ5 What are the teachers' perspectives on individual and collective EEG based learning while studying mathematics in primary schools? Do they vary with the teacher background characteristics?**

H5a: There is a significant influence of teacher characteristics on the perceptions of individual and collective EEG usage.

1. The responses to the questionnaire with respect to the three dimensions of EEG using the individual and collective modes was separated based on the teacher characteristics and subjected to ANOVA.

The following are the study variables (Table 6.4)

Table 6.4: The study variables for EEG Usage

| Teacher characteristics | EEG Perception of Teachers | | |
|---|---|---|---|
| | 1. Individual-collective EEG readiness | 2. Usefulness of EEG tools | 3. Impact of EEG Methods on Learner Achievement |
| A. Education level | | | |
| B. Age | | | |
| C. Gender | | | |
| D. Designation | | | |
| E. Experience | | | |
| F. Course taught | | | |
| G. Training received in EEG | | | |
| H. Type of EEG | | | |

2. Statistical procedure:

vii. Hypotheses:

$H_0$: $\mu A = \mu B = \mu C = \mu D = \mu E = \mu F = \mu G = \mu H$ (There is no difference based on gender)

$H_1$: Not all eight means are equal (There is a difference based on gender)

viii. $\alpha = .05$

ix. Test statistic: F-statistic

x. Decision criteria: Reject $H_0$ and accept $H_1$ if p-value < .05

xi. Calculation: p-value =

xii. Conclusion: Based on the results of this sample and analysis the null hypothesis was accepted or rejected.

The results would indicate if the perception of the teachers varies and the extent of variance with reference to teacher background characteristics.

## 6.5. Ethical Issues

All research studies need to carefully consider ethical issues (Cohen, Manion and Morrison, 2011). This study followed the ethical guidelines for educational research outlined by the British Educational Research Association (BERA, 2011). The study received ethical approval by the Department of Education at the University of York. There were two stages to pass for obtaining the ethical permission for this research in Kuwait. First, a formal letter of approval was to be obtained from the Ministry of Education (Appendix 7). The Secretary to the Minister of Education was approached with a request letter with a mandatory disclosure that the research was solely for the academic research purpose and no harm in physical and mental form would take place for the students in the schools where the experimentation is carried out. Second, with this letter of approval the Principal of School in Kuwait where this research was carried out was contacted with a formal undertaking that the names of the participants were kept confidential and the data was used purely for academic research purpose. Further, it was declared that both the conditions of course delivery had relative advantages and disadvantages so one of the groups may have the experience of lesser effectiveness, however any disadvantage over such a short period of intervention of experiencing the less effective condition was considered to be justifiable.

## 6.6. Conclusions

Considering the literature on EEG, it was concluded that seven research questions were necessary to be answered in order to fill the research gap. Each of these questions further led to the postulation of a hypothesis for empirical testing. The first research question was to study the effect of individual and collective EEG on the academic achievement of learners while studying mathematics in primary school. The obvious choice was a completely randomized design with replication. It was concluded that the pre-test and post-test results of the students' performance was to be subjected to a one-tailed t-test. The second research question concerned the permanency of learning through individual and collective EEG in primary school.

It was concluded that the experimental procedure was to be same as the previous case except for the post-test scores which were to be obtained by testing the same students two weeks after the instruction to check the permanency of learning. The third research question was a gender-wise comparison to check the differential effect of individual and collective EEG on academic achievement. An independent sample t-test was chosen as the method to be used. The fourth research question was to check the gender-wise differential effect of learning through individual and collective EEG in terms of permanency of learning. The method remained the same but the post-test scores were obtained by testing the same students two weeks after the instruction to check the permanency of learning. The fifth and final research question aimed to study the teachers' perspectives on learning through the individual and collective forms of EEG and to observe if teacher background had an influence on their perceptions of EEG usage. The first part of the research questionnaire was qualitative in nature and hence the information was collected through some qualitative questions on the questionnaire survey of the teachers and a semi-structured interview with six teachers. The second part of the analysis was quantitative, so questionnaire survey and one way ANOVA were the obvious choice for the analysis. This chapter has listed all of the methods used in the mixed methods approach for this research.

# CHAPTER 7

# Findings: the students' test results

## 7.1. Introduction

The aim of the research was to assess the impact of EEG on mathematics learning in primary school when learning takes place in individual and collective modes and to make suggestions to enhance learning effectiveness. It is obvious that, to improve the effectiveness of its impact, the study should include both quantitative and qualitative analyses. This chapter records the findings obtained by adopting both of these approaches in a systematic manner to analyse the students' perspectives of EEG as measured through their performance in learning mathematics and the various hypotheses were tested using the standard tests and the results analysed.

## 7.2. Quantitative Analysis

This research depends on quantitative data and its analysis to a considerable extent. Quantitative analysis provides empirical evidence for the existence/non-existence of causation between a given set of variables. So, it is an authentic means of supporting the theoretical understanding of a situation through experimental validation. In this research study, several research questions demand a test of causation between a given set of variables and, hence, a quantitative approach to research was adopted, as and when required. The following paragraphs narrate the quantitative analysis undertaken in this research with reference to a research question and the corresponding hypothesis.

### 7.2.1. Influence of EEG on Academic Achievement

**RQ1 What is the effect of individual and collective EEG on the academic achievement of the learner while studying mathematics in primary school?**

**H1o: There is no statistically significant difference on the $p<0.05$ level between the averages of the sample members (individual and collective) in the pre- and post-application of the achievement test in mathematics.**

**Individual EEG**

Table 7.1: Paired Sample Statistics - Individual EEG

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Pre | 14.0811 | 37 | 1.21056 | .19902 |
| | Post | 16.0811 | 37 | 1.08981 | .17916 |

Table 7.2: Paired Sample t-test - Individual EEG

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95percent Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | Pre - Post | -2.00000 | .66667 | .10960 | -2.22228 | -1.77772 | -18.248 | 36 | .000 |

The Null hypothesis is rejected hence,

There is a statistically significant difference on the $p<0.05$ level between the averages of the sample members of individual EEG in the pre- and post-application of the achievement test in mathematics (Table 7.1 & 7.2).

Thus, individual EEG produces a significant improvement in student achievement in mathematics.

**Collective EEG**

Table 7.3: Paired Sample Statistics - Collective EEG

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Pre | 12.8919 | 37 | 1.10010 | .18085 |
| | Post | 16.7838 | 37 | 1.33615 | .21966 |

Table 7.4: Paired Sample t-test - Collective EEG

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95percent Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | Pre - Post | -3.89189 | 1.44883 | .23819 | -4.37495 | -3.40883 | -16.340 | 36 | .000 |

The Null hypothesis is rejected hence,

There is a statistically significant difference on the $p<0.05$ level between the averages of the sample members of collective EEG in the pre- and post-application of the achievement test in mathematics (Table 7.3 & 7.4).

It is implied that collective EEG produces a significant improvement in student achievement in mathematics.

Therefore, it can be concluded that both individual and collective modes are likely to improve attainment.

### 7.2.2. Influence of EEG on Permanency of Learning

**RQ2 What is the effect of individual and collective EEG on the permanency of learning while studying mathematics in primary schools?**

**$H_{2o}$: There is no statistically significant difference on the $p<0.05$ level of the averages of the sample members (individual EEG) in the pre- and post-application on the test for maintaining the effect of learning (permanency of learning) in mathematics.**

Table 7.5: Paired Sample Statistics - Individual EEG

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Pre | 14.0811 | 37 | 1.21056 | .19902 |
| | Post | 16.1622 | 37 | 1.21366 | .19952 |

Table 7.6: Paired Sample t-test - Individual EEG

| | | Paired Differences | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95percent Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | t | df | Sig. (2-tailed) |
| Pair 1 | Pre - Post | -2.08108 | 1.23330 | .20275 | -2.49228 | -1.66988 | -10.264 | 36 | .000 |

The Null hypothesis is rejected, hence

There is a statistically significant difference on the $p<0.05$ level of the averages of the sample members (individual EEG) in the pre- and post-application of the test for maintaining the effect of learning (permanency of learning) in mathematics (Tables 7.5 & 7.6).

Thus, individual EEG produces a significant improvement in the permanency of student achievement in mathematics.

**Collective EEG**

Table 7.7: Paired Sample Statistics - Collective EEG (Permanency)

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Pre | 12.8919 | 37 | 1.10010 | .18085 |
| | Post | 16.0541 | 37 | 1.35290 | .22241 |

Table 7.8: Paired sample t-test - Collective EEG (Permanency)

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95percent Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | Pre - Post | -3.16216 | 1.42426 | .23415 | -3.63704 | -2.68729 | -13.505 | 36 | .000 |

The null hypothesis is rejected, hence there is a statistically significant difference in the $p<0.05$ level for the averages of the sample members (collective EEG) in the pre- and post-application of the test for maintaining the effect of learning (permanency of learning) in mathematics (Tables 7.7 & 7.8).

Thus, collective EEG produces a significant improvement in the permanency of student achievement in mathematics.

### 7.2.3. Differential Effect of Individual and Collective Learning through EEG

RQ3: What is the differential effect produced by individual and collective EEG on the academic achievement of the learner while studying mathematics in primary school?

**$H_{3o}$: There is no statistically significant difference in the $p<0.05$ level between the averages of the sample members (individual and collective EEG) in the pre- and post-test application of the achievement test in mathematics.**

Table 7.9: Group Statistics Individual-Collective EEG Academic Achievement

| | VAR00001 | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| VAR00002 | 1.00 (Individual) | 37 | 2.0000 | .66667 | .10960 |
| | 2.00 (Collective) | 37 | 3.8919 | 1.44883 | .23819 |

Table 7.10: Independent Samples t-Test Individual-Collective EEG Academic Achievement

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95percent Confidence Interval of the Difference Lower | Upper |
| VAR00002 | Equal variances assumed | 23.97 | .00 | -7.21 | 72 | .000 | -1.89 | .26219 | -2.41 | -1.37 |
| | Equal variances not assumed | | | -7.21 | 50.59 | .000 | -1.89 | .26 | -2.42 | -1.37 |

The null hypothesis is rejected (Sig. < 0.05); thus, it is concluded that there is a significant difference in the learning produced by the individual and collective modes of learning mathematics using EEG in favour of the collective mode (Mean 2 to 3.89) (Tables 7.9 & 7.10).

This result is consistent with previous studies (Bates et al., 2004; Enos et al., 2003 and Weithoff, 2004; Kebritchi et al., 2008; Meluso et al., 2012; and Yang et al., 2013), even though the earlier studies were not specifically focused on the topic (mathematics) or context (V grade students) of this research. The edge obtained by collective gaming in achieving the educational outcomes was mainly due to EEG's engaging environment and the provision for interaction between the students in the collective learning mode.

This point is substantiated by a conversation between two students during the learning process which was recorded by the researcher:

*Student A: What is this 'C' button on the EEG in iPad? Where can I use it?*

*Student B: I used it to cancel what has been typed.*

*Student A: Can you show me on your gadget how to use it?*

*Student B: See this, I want to add 52 and 48 and by mistake I typed 46 now I can use this key 'C' to cancel 6 which is a wrong entry in place of 8 and type 8 which is correct and then press the + button to add.*

*Student A: Well, that is quite useful; let me try it at my own.*

So, there is an element of curiosity in the EEG with new features and students are ready to help their classmates and they feel that it is easier to interact with them than the teacher. Moreover, there is a competitive spirit among the students and they willingly embrace the learning process. The students were found to repeat the tasks until they reach the desired outcome as they were in a collective mode of learning which was lacking in the case of individual learning where the students would give up after a few attempts. Thus, the collective mode could achieve better results, as revealed through the hypothesis testing.

The research question that was to be addressed specifically focused on whether the individual or collective mode of EEG-based teaching differed in its ability to achieve the learning outcome as measured through the marks obtained. The results clearly indicate that there exists a significant difference and that the collective mode of EEG is superior in achieving this outcome. However, it must be noted that the context is 5$^{th}$ grade schoolchildren and the topic is basic mathematical operations. So, the school may benefit from this study and start spending a stipulated amount of time using the collective mode of EEG-based teaching.

#### 7.2.4. Differential Effect of individual and collective EEG on Permanency of Learning

RQ4: What is the differential effect of individual and collective EEG on the permanency of academic achievement of the learner while studying mathematics in primary school?

**$H_{4o}$: There is no statistically significant difference in the p<0.05 level between the averages of the sample members (individual and collective EEG) in the pre- and post-test application of the permanency of learning in the achievement test in mathematics.**

Table 7.11: Group Statistics Individual-Collective EEG Permanency of Learning

| | VAR00001 | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| VAR00002 | 1.00 (Individual) | 37 | 2.0811 | 1.23330 | .20275 |
| | 2.00 (Collective) | 37 | 3.1622 | 1.42426 | .23415 |

Table 7.12: Independent Samples Test Individual-Collective EEG Permanency of Learning

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95percent Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| VAR00002 | Equal variances assumed | .70 | .405 | -3.49 | 72 | .001 | -1.08 | .31 | -1.69 | -.46 |
| | Equal variances not assumed | | | -3.49 | 70.55 | .001 | -1.08 | .31 | -1.69 | -.46 |

The null hypothesis is rejected (Sig. < 0.05); thus, it is concluded that there is a significant difference in maintaining permanency of learning in mathematics while working on individual and collective EEG favouring collective EEG (Mean 2.08 to 3.16) (Tables 7.11 & 7.12).

This result is consistent with previous studies (Crookall et al., 1987 and Dempsey et al., 2002; Kinzie & Joseph, 2008; Sarama and Clements, 2009; Kim & Chang 2010; and Hwang & Wu, 2012) even though the earlier studies were based on different settings in terms of geographical location and the respondents' grades. The edge obtained by collective gaming in achieving the educational outcomes was mainly due to EEG's ability to reinforce the concepts learnt which can occur in several situations during collective EEG learning. Whereas the sum is solved only once under the individual mode of learning, during the collective mode of learning, there could be situations in which the students may interact with each other and repeat the entire sum either during the teaching or through learning through interaction with others. The social dimension added to learning through collective learning makes all the difference, and has the ability to induce permanency in learning because a lot of interaction takes place during learning which makes the learning experience memorable to the students (Ugurel & Morali, 2010). The permanency is also because of the fun element attached to group learning (Swan & Marshall, 2009).

During the collective learning through EEG process, the following conversation between the students was recorded by the researcher:

*A: How did you solve 32 + '-' = 40 using the gadget?*

*B: I just kept on adding different numbers to 32 to check if it gets me 40 and found that when I added 8 it resulted in 40 and thus I found that the missing number is 8.*

*A: But should we actually press all the numbers from 1 to 9 to check it?*

*B: I guess yes.*

*A: I don't think it is necessary, there must be an easier way. See that student 'C' did it very fast why don't we ask him?*

*B: Yes, let's ask him.*

*Both A and B approached student C.*

*B: Hello, we have a problem, A says you did the sums very fast and we are interested to know how you found the answer to 32 + '-' = 40 using the gadget.*

*C: I did it this way. See, if a number is to be added to 32 to make it 40, that means if we subtract that 32 from 40 it must give me that number. So, I subtracted 32 from 40 and I got 8.*

*A: but how are you so sure about it?*

*C: I checked by adding the answer 8 to 32 again through my gadget to check if it makes 40 and I got it. So, I am sure.*

*A and B both repeat that exercise and check it themselves and say, "w=We too got it. It is really simple, we don't have to add all the numbers to see if it makes 40 but directly obtain that number".*

*A: But still I have a doubt. Does this work for any numbers?*

*C: I guess yes, it must work because when a number is to be added to get the right hand side (RHS) number of the equation, if we subtract the number from the RHS number, the number to be added is obtained.*

*B: What if the number has to be subtracted from a number to obtain a new number?*

*A: Wait, we should try with our own problem say 46 – "-" = 32 then how to get the missing number?*

*B: We must subtract 32 from 46 to get the missing number.*

*A & C: yes we should do it….it gives us 14.*

*A: We should verify whether it is right.*

*C: Yes try 46 minus 14 it gives 32 so our answer is correct.*

*All three thanked each other and dispersed.*

The above conversation is not only interesting but it also demonstrates how the students are self-directed towards achieving their goal. Their inquisitiveness and social interaction makes learning fun and the questions naturally emerge from them. They not only solve the problem but also build their own techniques to solve the problem and verify it. The way they have evolved their own way of solving the problem and the interactive mode of finding alternative ways of doing it have the ability to make the assimilation of knowledge permanent. In the individual mode of learning based on the earlier knowledge and the knowledge imparted through the teacher, the learner may solve the problem and try to understand it in his/her own way but there is no scope for building the collective memory of the group. In contrast, the collective model of EEG provides immense scope for the students to share their knowledge and the student who has solved a problem will be as excited as the knowledge seeker who asks doubts to share his/her acquired knowledge. Another point that was observed during the EEG exercise is that each learner was led to a deeper understanding of the problem and solution-seeking in his/her own way. This is the strength of collective EEG as observed during the field work.

The research question that was to be addressed specifically was whether the individual and collective modes of EEG-based teaching differed in terms of their ability to induce permanency in learning. The findings clearly indicate that there exist significant differences and that the collective mode of EEG is superior in achieving permanency of learning. As in the previous hypothesis, it must be noted that the context is $5^{th}$ grade schoolchildren and the topic is basic mathematical operations. So, the school may benefit from this study and start spending a stipulated amount of time on using the collective mode of EEG-based teaching.

### 7.2.5. Gender Influence on Learning through Individual and Collective EEG

RQ5: What is effect of gender of students on the learning of mathematics using individual and collective EEG?

**$H_{50}$: There is no statistically significant difference on the $p<0.05$ level between the averages of the sample members (individual and collective EEG) based on gender in the pre- and post-application of the achievement test in mathematics.**

Table 7.13: Group Statistics - Gender Difference (Individual EEG)

| | VAR00001 | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| VAR00002 | 1.00 (Individual) | 21 | 1.9048 | .62488 | .13636 |
| | 2.00 (Collective) | 16 | 2.1250 | .71880 | .17970 |

Table 7.14: Independent Samples Test - Gender Difference (Individual EEG)

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95percent Confidence Interval of the Difference Lower | Upper |
| VAR00002 | Equal variances assumed | .62 | .44 | -.99 | 35 | .33 | -.22 | .22 | -.67 | .23 |
| | Equal variances not assumed | | | -.97 | 29.83 | .34 | -.22 | .23 | -.68 | .24 |

Table 7.15: Group Statistics Gender Difference (Collective EEG)

| | VAR00001 | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| VAR00002 | 1.00 (Individual) | 21 | 4.0952 | 1.33809 | .29199 |
| | 2.00 (Collective) | 16 | 3.6250 | 1.58640 | .39660 |

Table 7.16: Independent Samples Test Gender Difference (Collective EEG)

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95percent Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| VAR00002 | Equal variances assumed | .04 | .83 | .97 | 35 | .34 | .47 | .48 | -.51 | 1.45 |
| | Equal variances not assumed | | | .95 | 29.23 | .35 | .47 | .49 | -.54 | 1.48 |

The null hypothesis cannot be rejected (Sig. > 0.05); thus, it is concluded that there is no significance difference between individual and collective EEG-based learning due to gender (Tables 7.13 to 7.16). In other words, both the male and female students are equally influenced by the two methods of EEG-based learning.

This result conflicts with those found by some earlier researchers (Papastergiou, 2009 and Kim & Chang, 2010) but agrees with those of others (Agosto, 2004; Kinzie & Joseph, 2008; Annetta, et al., 2009), even though the earlier studies were conducted in different settings in terms of geographical location and the respondents' grades. Thus, strictly speaking, the research takes the stand of only one group of researchers. It should be noted that, in a traditional setting like Kuwait, there is no free gender mix in the teaching-learning processes, although this situation has gradually been changing over the past few years and the media exposure has made society more open in terms of gender mix in comparison to yesteryear. Females have been given equal opportunities with male students in the field of both education and employment, and they now mix more liberally than ever before. This may mean that female students now perform on a par with male ones.

The research question that was to be addressed specifically was whether the individual and collective mode of EEG-based teaching differed with respect to gender. The results clearly indicate that there exists a significant difference and that the collective mode of EEG is superior in achieving permanency of learning. As with the previous hypothesis, it must be noted that the context is 5th grade schoolchildren and the topic is basic mathematical operations. So, the school may benefit from this study and start spending a stipulated amount of time using the collective mode of EEG-based teaching.

### 7.2.6. Gender Influence on the Permanency of Learning through Individual and Collective EEG

RQ6: What is the influence of gender of students on the permanency of learning of mathematics using individual and collective EEG?

**$H_{6o}$: There is no statistically significant difference on the p<0.05 level between the averages of the sample members (individual and collective EEG) based on gender in the pre- and post-application on the permanency of learning in achievement test for mathematics.**

Table 7.17: Group Statistics - Gender difference Permanency of Learning (Individual EEG)

| | VAR00001 | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| VAR00002 | 1.00 (Individual) | 21 | 1.8095 | 1.28915 | .28132 |
| | 2.00 (Collective) | 16 | 2.4375 | 1.09354 | .27339 |

Table 7.18: Independent Samples Test - Gender difference Permanency of Learning (Individual EEG)

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95percent Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Diff. | Lower | Upper |
| VAR00002 | Equal variances assumed | .811 | .37 | -1.57 | 35 | .13 | -.63 | .40 | -1.44 | .19 |
| | Equal variances not assumed | | | -1.6 | 34.54 | .12 | -.63 | .39 | -1.42 | .17 |

Table 7.19: Group Statistics - Gender difference Permanency of Learning (Collective EEG)

| | VAR00001 | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| VAR00002 | 1.00 (Individual) | 21 | 3.3810 | 1.39557 | .30454 |
| | 2.00 (Collective) | 16 | 2.8750 | 1.45488 | .36372 |

Table 7.20: Independent Samples Test - Gender difference Permanency of Learning (Collective EEG)

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95percent Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| VAR00002 | Equal variances assumed | .014 | .91 | 1.07 | 35 | .29 | .51 | .47 | -.45 | 1.46 |
| | Equal variances not assumed | | | 1.07 | 31.71 | .29 | .51 | .47 | -.46 | 1.47 |

The null hypothesis cannot be rejected (Sig. > 0.05); thus, it is concluded that there is no significance difference between individual and collective EEG-based learning due to gender in terms of permanency of learning (Tables 7.17 to 7.20). In other words, both the male and female students are equally influenced by the two methods of EEG-based learning in terms of the permanency of learning. There has been little earlier research on the permanency of learning in terms of gender difference in the Arab context, even though there exists evidence of male dominance in learning through electronic means (Ke and Grabowski, 2007). However, a few studies have failed to find any gender difference with regard to permanency of computer-based learning (Abdu-Raheem, 2012). It should be noted that, in a traditional set-up like Kuwait, there is no free gender mix in the teaching/learning process, and many researchers have observed male domination (Hartmann & Klimmt, 2006 and Kinzie & Joseph, 2008) which has been categorically disproved through this research, but things have been slowly changing in the past few years and the media exposure has made society more open in terms of gender mix in comparison to yesteryear. Females have been given equal opportunities to male students in terms of education and employment and now mix more liberally than ever before. This may mean that the female students now perform on a par with the male ones.

The student interactions during the individual and collective modes of EEG usage were captured and it was found that the students were highly excited about the new methodology, and mixing freely and solving the problems with the same interest and enthusiasm they exhibit while playing videogames. The entertainment value is thus confirmed and they conveyed that the whole class was in a highly participative mood and enthusiastically interacted with each other during the use of the collective mode. Thus, the EEG-based class enhances group learning, adds a social dimension to learning, enhances the communication skills of the students, develops team spirit, promotes knowledge dissemination among students, and teaches them to share ideas.

The specific research question that was to be addressed was whether the individual and collective modes of EEG affect the permanency of mathematics learning in primary school in terms of gender. The findings indicate that there exist no significant differences between the individual and collective modes of EEG in achieving permanency in learning. It must be noted that the context is 5th grade schoolchildren and the topic is basic mathematical operations. So, the school may benefit from this study that confirms that either the individual or collective mode of EEG-based learning will have a similar influence on the permanency of learning, irrespective of the gender.

### 7.3. Conclusions

This chapter has answered the research questions pertaining to student performance through EEG usage in the individual and collective modes. It can be concluded that both individual and collective EEG leads to a significant improvement in student achievement in mathematics as well as permanency of learning, and also that the collective mode of EEG was superior to the individual mode in terms of both learning outcome achievement and permanency of learning. The study revealed that the gender of the student had no influence on learning outcome achievement or permanency of learning. These conclusions provide valuable insights into this research area, which led to the development of suggestions and recommendations for the Ministry of Education, designed to enhance the effectiveness of EEG-based learning.

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# CHAPTER 8

# Findings: teacher test results

## 8.1. Introduction

This chapter records the quantitative analysis of the teachers' perceptions of the usage of EEG in the individual and collective modes of learning. The teacher perspectives have been analysed in terms of the descriptive statistics, and then through inferential statistics in the form of hypothesis testing. The results obtained through the ANOVA and Multiple Comparison have been analysed and the hypotheses tested to obtain the results. The findings from the hypotheses testing have been presented.

## 8.2. Quantitative Analysis

### 8.2.1. Teachers' Perspectives on EEG

The teachers' perspectives on EEG have been studied in terms of three distinct aspects: 1. Knowledge of Computer Usage (KCU) on the part of the students; 2. Usefulness of EEG; and 3. Learner achievement. The following sections explain the descriptive and inferential statistics obtained through the analysis of the results obtained.

**Descriptive Statistics**

***Teacher Perceptions on Individual-collective EEG Readiness***

**RQ3 What are the teachers' perspectives on individual and collective EEG based learning while studying mathematics in primary schools? Do they vary with the teacher characteristics?**

The following sections answer the first part of the research question. The second part will be addressed in the next chapter through the hypothesis testing.

### *1. Knowledge of Computer Usage*

Knowledge of Computer Usage (KCU) was measured in terms of nine specific indicators through the questionnaire survey. The responses of the teachers in the form of descriptive statistics for the individual items are provided in Table 8.1 and Figure 8.1.

Table 8.1: The Descriptive Statistics regarding Knowledge of Computer Usage (N = 124)

| **Item** | **Mean** | **Std. Dev.** | **Disagree (percent)** | **Agree (percent)** | **Neutral (percent)** |
|---|---|---|---|---|---|
| 1. The learner is expected to be a computer user at home | 4.0 | 1.0 | 3.2 | 35.1 | 61.7 |
| 2. The learner is expected to play electronic games at home | 3.6 | 1.1 | 8.9 | 29.85 | 61.3 |
| 3. The learner is a mathematic s iPAD user | 3.6 | 1.3 | 10.1 | 29.8 | 60.1 |
| 4. The learner has learnt the iPAD at school | 3.8 | 1.0 | 4.85 | 33.9 | 61.3 |
| 5. Parents have helped the learner to play iPAD | 3.9 | 1.2 | 5.65 | 35.9 | 58.5 |
| 6. The learner is efficiently using iPAD games in learning | 3.7 | 1.1 | 6.05 | 30.25 | 63.7 |
| 7. The learners responds quickly during mathematics activities | 4.0 | 1.0 | 3.2 | 36.7 | 60.1 |
| 8. The learner performs highly while playing mathematics | 3.8 | 1.0 | 4.85 | 33.85 | 61.3 |
| 9. The learner is listening, observing and making appropriate choices | 3.6 | 1.2 | 8.1 | 31.85 | 60.1 |
| **Average** | **3.8** | **1.1** | **6.1** | **33.0** | **60.9** |

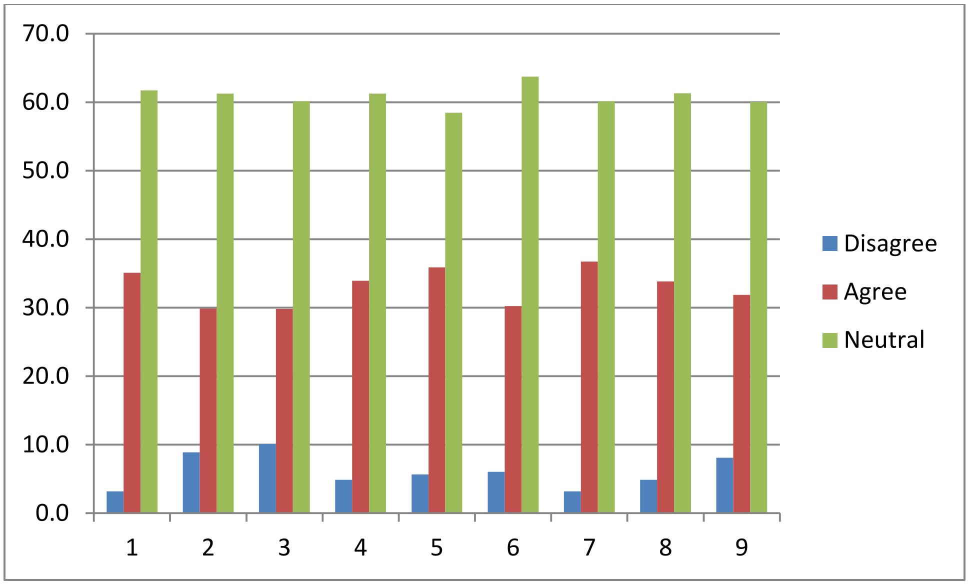


Figure 8.1: The descriptive statistics for KCU

Relatively higher proportion of the teachers (33 percent) agreed that students should have some exposure to electronic gaming, while only 6 percent disagreed, and the majority were neutral on their point. Thus, it can be inferred that the teachers expect students to have been exposed to some form of EEG beforehand for EEG-based teaching in class to be successful.

### 2. *Parents' Skills (PRS)*

Relatively higher proportion of the teachers (31.3 percent) agreed that PRS has a role to play in the success of EEG, while only 7.5percent disagreed, and the majority were neutral on this point. The responses of the teachers in the form of descriptive statistics for the individual items are presented in Table 8.2 and Figure 8.2.

Table 8.2: The Descriptive Statistics for PRS (N = 124)

| Item | Mean | Std. Dev. | Disagree (percent) | Agree (percent) | Neutral (percent) |
|---|---|---|---|---|---|
| 1. The parents frequently support the learners in playing EG in mathematics | 3.7 | 1.1 | 6.1 | 29.9 | 64.1 |
| 2. The parents support the learners in playing EG in mathematics | 3.7 | 1.2 | 7.7 | 30.3 | 62.1 |
| 3. Parents rather than the school select the Math Games | 3.9 | 1.1 | 6.1 | 34.7 | 59.3 |
| 4. Parents are less keen to select the games | 3.7 | 1.2 | 7.7 | 33.5 | 58.9 |
| 5. Parents are familiar with EG as per the maths chapters in the maths book | 3.8 | 1.0 | 5.3 | 32.3 | 62.5 |
| 6. Parents guide the learner on answering the questions | 3.6 | 1.1 | 6.1 | 30.3 | 63.7 |
| 7. Parents are familiar with the speed limit for answering the questions | 3.6 | 1.1 | 7.7 | 27.9 | 64.5 |
| 8. The mother is mainly involved in teaching the learner | 3.5 | 1.3 | 13.7 | 31.5 | 54.9 |
| **Average** | **3.7** | **1.1** | **7.5** | **31.3** | **61.2** |

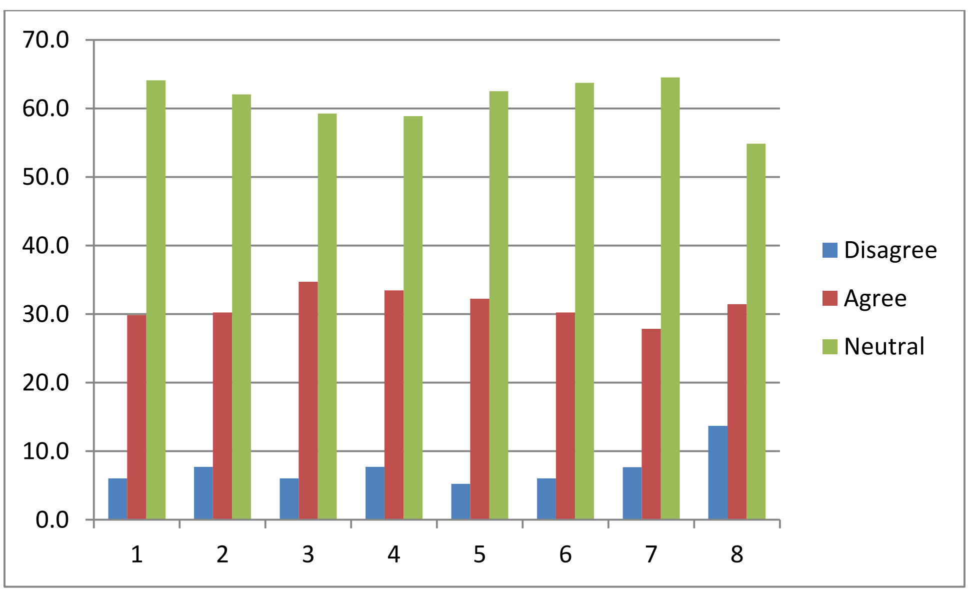


Figure 8.2: The descriptive statistics for PRS

### *3. Selection of Electronic Game*

Relatively higher proportion of the teachers (31.1 percent) agreed that the selection of EEG has a role to play in its success in classroom teaching (Table 8.3 and Figure 8.3), while only 7.8 percent disagreed, and the majority were neutral on this point. Thus, it can be inferred that the teachers expect that EEG selection plays a role in the success of EEG-based teaching in class.

Table 8.3: The Descriptive Statistics for EEG Selection (N = 124)

| **Item** | **Mean** | **Std. Dev.** | **Disagree (percent)** | **Agree (percent)** | **Neutral (percent)** |
|---|---|---|---|---|---|
| 1. The selected game was a board shape rather than cardboard sheets | 3.5 | 1.3 | 13.7 | 31.5 | 54.9 |
| 2. The selected game is used as a Group Learning Tool | 3.9 | 1.0 | 2.8 | 32.3 | 65.0 |
| 3. The selected game is used as an individual Learning Tool | 3.8 | 1.0 | 6.5 | 34.3 | 59.3 |
| 4. Magic Math is an appropriate EG for 10-11 year-old learners | 3.7 | 1.2 | 6.9 | 31.1 | 62.1 |
| 5. Math kid is an appropriate EG for 10-11 year-old learners | 3.5 | 1.2 | 8.1 | 26.7 | 65.3 |
| 6. Kids Math is an appropriate electronic game for 10-11 year-old learners | 3.6 | 1.2 | 8.9 | 30.7 | 60.5 |
| | **3.6** | **1.1** | **7.8** | **31.1** | **61.1** |

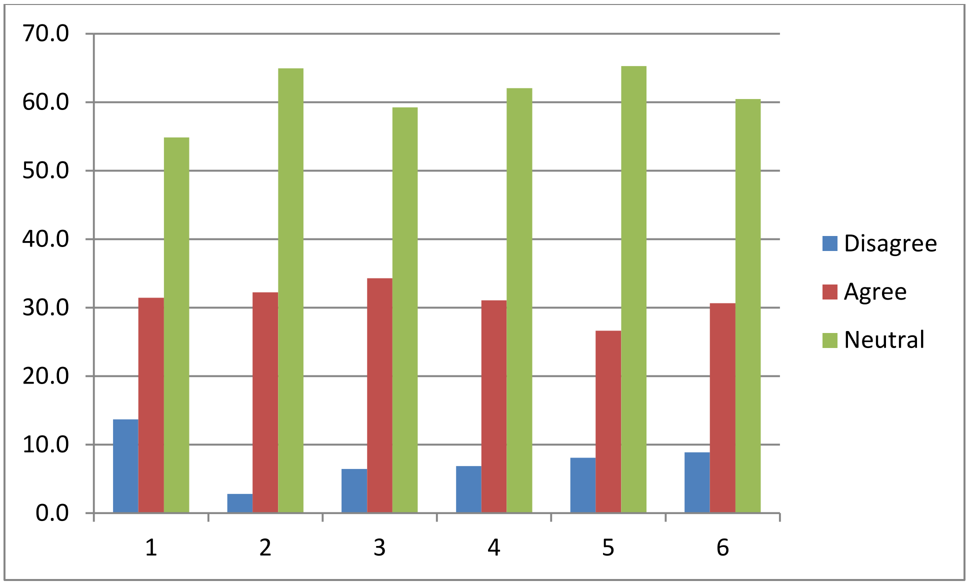


Figure 8.3: The descriptive statistics for EEG selection

### ***Teacher Perceptions of the Usefulness of EEG Tools***

**1. EEG Type (EGT)**

Relatively higher proportion of the teachers (39.6percent) agreed that EGT has a role to play in the success of EEG (Table 8.4 & figure 8.4), while only 2.5percent disagreed and the majority were neutral on this point. Thus, it can be inferred that the teachers perceive that EGT type has a role to play in the success of EEG-based teaching in class.

Table 8.4: The Descriptive Statistics for the Importance of EGT (N = 124)

| Item | Mean | Std. Dev. | Disagree (percent) | Agree (percent) | Neutral (percent) |
|---|---|---|---|---|---|
| 1. The selected game has to offer the learner an insight into how to approach mathematic skills | 4.1 | 0.9 | 3.2 | 40.3 | 56.5 |
| 2. The game has to offer options for learning how to avoid making mistakes | 4.2 | 1.1 | 4.0 | 40.4 | 55.7 |
| 3. The game should use different approaches to answer the questions to help learners to work out that there are many ways to answer | 4.1 | 0.9 | 1.6 | 39.1 | 59.3 |
| 4. The selected game should be able to attract attention to solving the questions | 4.2 | 0.9 | 1.2 | 38.7 | 60.1 |
| | **4.1** | **0.9** | **2.5** | **39.6** | **57.9** |

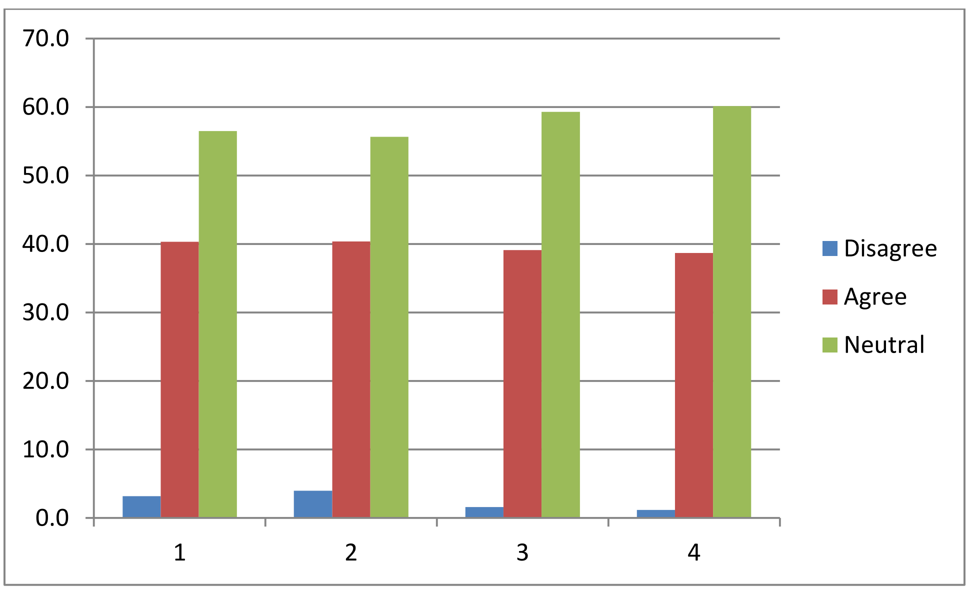


Figure 8.4: The descriptive statistics for the importance of EGT

**2. Time Management Skills (TMS)**

Relatively higher proportion of the teachers (40.9 percent) agreed that TMS has a role to play in the success of EEG (Table 8.5 & Figure 8.5), while only 2.4 percent disagreed, and the majority were neutral on this point. Thus, it can be inferred that the teachers expect that TMS has a role to play in the success of EEG-based teaching in class.

Table 8.5: The Descriptive Statistics for TMS (N = 124)

| Item | Mean | Std. Dev. | Disagree (percent) | Agree (percent) | Neutral (percent) |
|---|---|---|---|---|---|
| 1. The Electronics Information subtest of the selected game consists of multiple choice questions, which must be answered in 9 minutes. | 4.3 | 0.9 | 2.4 | 42.0 | 55.7 |
| 2. The Electronics Information subtest of the selected game consists of missing answer choice questions, which must be answered in 4 minutes. | 4.2 | 0.9 | 1.6 | 39.1 | 59.3 |
| 3. The Electronics Information subtest of the selected game consists of rating or ranking multiple choice questions, which must be answered in 4 minutes. | 4.2 | 0.9 | 3.2 | 41.6 | 55.3 |
| | **4.2** | **0.9** | **2.4** | **40.9** | **56.7** |

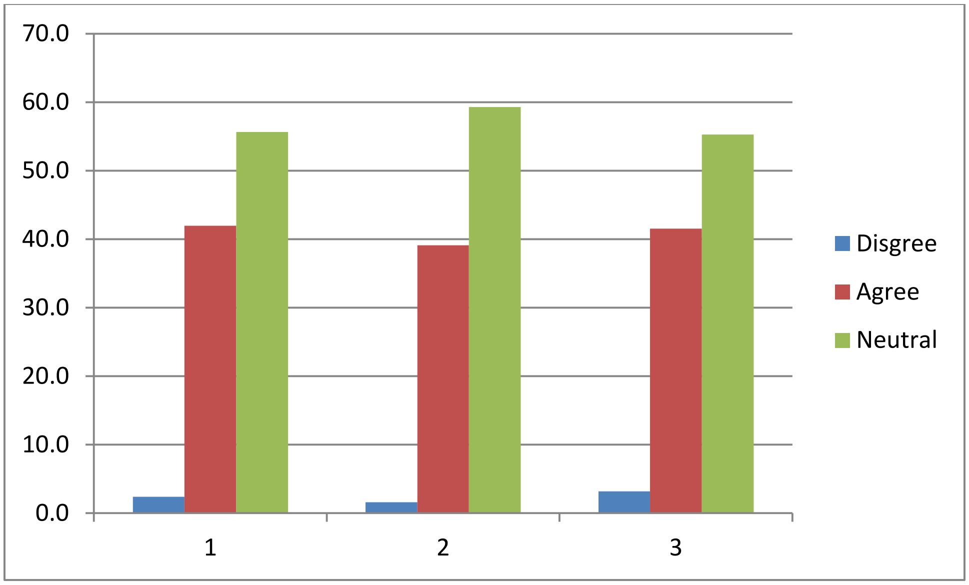


Figure 8.5: The descriptive statistics for TMS

***Teacher Perceptions of the Impact of EEG Methods on Learner Achievement***

***1. Device Learning Skill & Concept (DLC)***

Relatively higher proportion of the teachers (36.6 percent) agreed that DLC has a role to play in the success of EEG (Table 8.6 & Figure 8.6), while only 4.3 percent disagreed and the majority were neutral on this point. Thus, it can be inferred that the teachers expect that DLC has a role to play in the success of EEG-based teaching in class.

Table 8.6: The Descriptive Statistics for DLC (N = 124)

| Item | Mean | Std. Dev. | Bad (1) (percent) | Poor (2) (percent) | Neutral (percent) |
|---|---|---|---|---|---|
| 1. Device practices include individual exploration | 3.7 | 1.1 | 7.3 | 31.1 | 61.7 |
| 2. Device practices include, peer interaction and small group work | 4.0 | 1.1 | 4.9 | 36.3 | 58.9 |
| 3. Device practices emphasize the use of multiple approaches to problem-solving, | 4.2 | 1.0 | 2.8 | 40.8 | 56.5 |
| 4. Device practices emphasize active student ability | 4.1 | 0.9 | 2.8 | 38.3 | 58.9 |
| 5. Device practices emphasize the importance of linking mathematics to students' daily life | 4.1 | 1.0 | 2.8 | 37.5 | 59.7 |
| 6. Device practices emphasize the use of a multiple approach to problem-solving | 4.0 | 1.1 | 5.2 | 35.5 | 59.3 |
| | **4.0** | **1.0** | **4.3** | **36.6** | **59.2** |

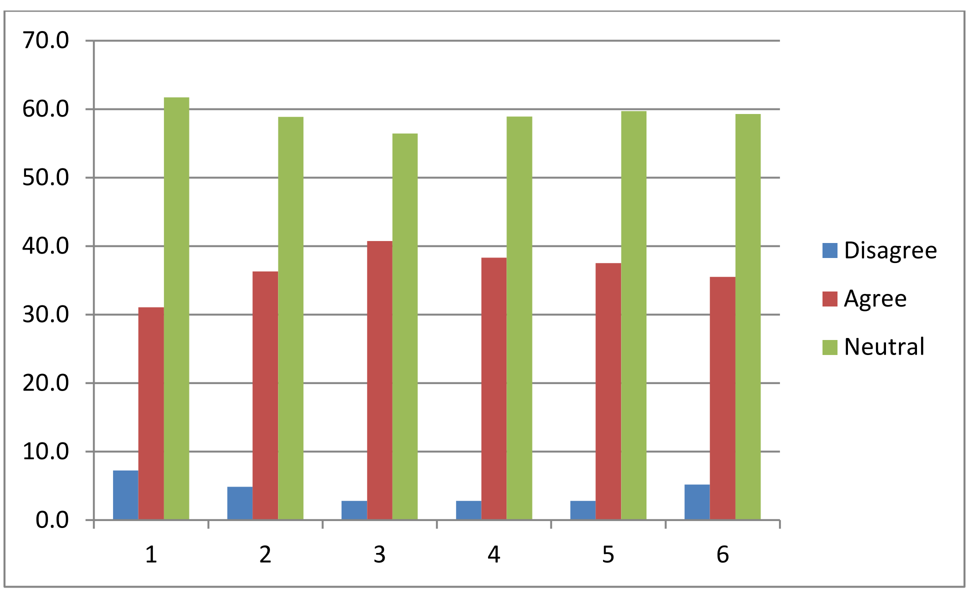


Figure 8.6: The descriptive statistics for DLC

**2. Teacher Effectiveness (TEF)**

Relatively higher proportion of the teachers (36.5 percent) agreed that TEF has a role to play in the success of EEG (Table 8.7 & Figure 8.7), while only 3.6 percent disagreed, and the majority were neutral on this point. Thus, it can be inferred that the teachers expect that TEF has a role to play in the success of EEG-based teaching in class.

Table 8.7: The Descriptive Statistics for TEF (N = 124)

| Item | Mean | Std. Dev. | Good (4) (percent) | V. Good (5) (percent) | Neutral (percent) |
|---|---|---|---|---|---|
| 1. You are presenting a lecture as per a specific textbook | 4.2 | 0.9 | 1.6 | 38.7 | 59.7 |
| 2. You are helping students to think critically | 4.3 | 0.9 | 2.4 | 42.0 | 55.7 |
| 3. You are concerned with the EG subject area | 4.2 | 0.9 | 1.6 | 39.1 | 59.3 |
| 4. You are applying student-Device knowledge in teaching | 4.2 | 0.7 | 0.8 | 34.3 | 65.0 |
| 5. You are concerned with reforming instructional practices in mathematics | 4.2 | 0.9 | 3.2 | 41.6 | 55.3 |
| 6. You are concerned with the importance of examining the effects and relationship among the types of instructional practices that students receive | 4.1 | 0.9 | 2.4 | 38.3 | 59.3 |
| 7. You are helping learners with their scientific achievements and attitudes towards mathematics | 3.7 | 1.1 | 9.7 | 31.1 | 59.3 |
| 8. You are helping learners with their scientific achievement and attitudes towards EG | 4.0 | 0.8 | 1.6 | 23.8 | 74.6 |
| 9. Teachers' act of asking questions helps to keep students actively involved in lessons | 4.1 | 1.0 | 4.0 | 37.5 | 58.5 |
| 10. Teachers allow students, while answering questions, to have an | 4.0 | 1.1 | 5.6 | 35.5 | 58.9 |

| | | | | | |
|---|---|---|---|---|---|
| opportunity to express their ideas and thoughts openly | | | | | |
| 11. Teachers help learners to develop their mathematics skills | 4.2 | 0.9 | 6.5 | 40.3 | 53.2 |
| **Average** | **4.1** | **0.9** | **3.6** | **36.5** | **59.9** |

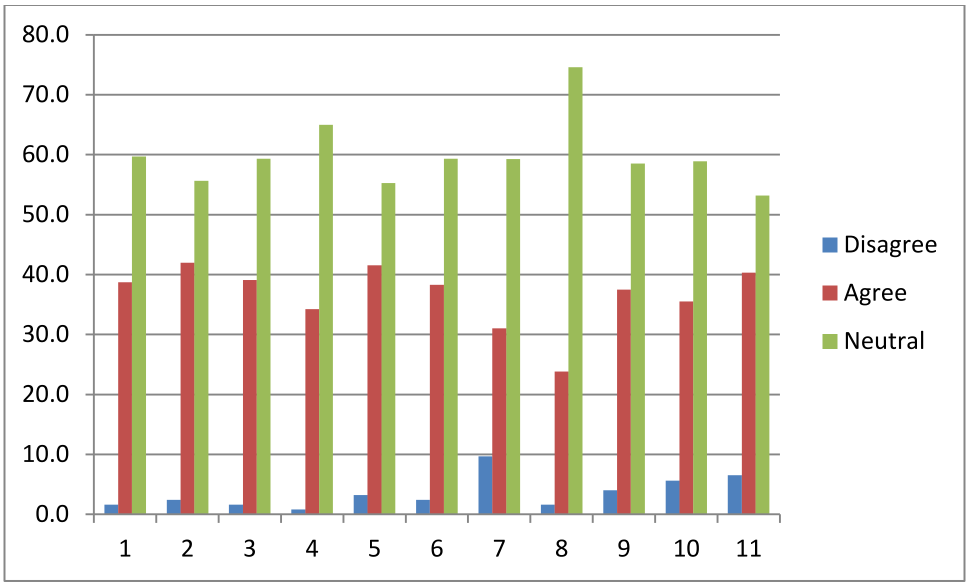


Figure 8.7: The Descriptive Statistics for Teacher Computer Skills

## 8.3. Conclusions

This chapter provides the quantitative basis for the conclusions about the teachers' perceptions about EEG usage in primary education. Unfortunately, in each dimension, the majority of the teachers adopt a neutral stand. So, the conclusions can be based only on a comparative analysis of their agreement and disagreement with the indicators of measurement on the questionnaire, ignoring those who remain neutral. This suggests that a large proportion of teachers still have to be 'won over' in terms of the positive impact of various elements of EEGs. There were nine specific indicators of measurement of how important it is for student to have KCU before taking up a course that uses EEG as the medium for learning. Through the response, it can be concluded that the teachers feel that KCU is necessary for the success of EEG, as indicated by the descriptive statistics. Regarding PRS of computer usage, again the teachers feel that this plays a role in the success of EEG adoption in the classroom. The teachers also feel that the selection of the most appropriate EEG also plays a dominant role in the success of EEG usage. In terms of the usefulness of EEG tools in teaching, the teachers perceive that EEG type and time management skills play a dominant role. In terms of the impact of EEG methods on learner achievement, device learning skill and concept and teacher effectiveness are perceived to be important by the teachers.

Thus, it can be concluded that successful EEG in the context of primary education as a medium for teaching mathematics can be achieved via two approaches. The first option would be to provide an ambiance for the students, teachers and parents so that an awareness could be created by the teachers among the parents and students regarding the necessity of computer skills, the role of the parents in motivating their children towards computer-based learning, introducing time management skills to the students at a very early stage, and also the role of the teachers in choosing the most appropriate electronic game. The second option would be to offer training to teachers on EEG usage in primary education so that their perceptions about the success of this can be influenced positively. The fact that the vast majority of teachers remained neutral in their response to the specific indicators of measurement of EEG usage itself indicates that they do not perceive that EEG can play a serious role in disseminating knowledge through either the individual and collective modes. So, training programmes, workshops and conferences could be arranged to promote healthy interaction among the teaching faculty, and the teachers might also be sponsored to attend conferences in order to present their views to their counterparts across the world and learn through experience sharing. Finally, as a large proportion of the teachers were in the category of 'neutral' to the survey there is a need to give teachers more experience of EEGs, so that they can see the benefits at first hand.

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# CHAPTER 9

# Findings: Effect of Teacher Characteristics

## 9.1. Introduction

This chapter deals with the influence of teacher characteristics on their perceptions about EEG usage in the individual and collective modes. In this chapter, the findings from the quantitative analysis in the form of inferential statistics are presented. First, the findings on the effect of overall teacher characteristics' influence on the perceptions of EEG usage are presented. More specifically, it examines the effect of the teacher characteristic variables (educational qualifications, age, gender, designation, experience, course taught, and type of game used) on their perceptions about EEG usage in the primary classroom.

## 9.2. Quantitative Analysis – Inferential Statistics

### 9.2.1. Influence of Educational Qualifications on Individual/Collective EEG Effectiveness Perceptions

To test the influence of the educational qualifications of teachers on individual-collective EEG readiness perception, the following hypothesis was tested.

$H_{6aa}$: Teacher educational qualifications affect their individual-collective readiness for EEG.

Table 9.1: The ANOVA of the EDN of Teachers regarding individual-collective readiness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 4.564 | 2 | 2.282 | 3.914 | .023 |
| Within Groups | 70.557 | 121 | .583 | | |
| Total | 75.121 | 123 | | | |

Table 9.2: Multiple Comparison of EDN levels with individual-collective Readiness

Tukey HSD

| (I) Education | (J) Education | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | .44538 | .15963 | .017 | .0666 | .8242 |
| | 3.00 | .10714 | .19361 | .845 | -.3523 | .5666 |
| 2.00 | 1.00 | -.44538 | .15963 | .017 | -.8242 | -.0666 |
| | 3.00 | -.33824 | .21519 | .262 | -.8489 | .1724 |
| 3.00 | 1.00 | -.10714 | .19361 | .845 | -.5666 | .3523 |
| | 2.00 | .33824 | .21519 | .262 | -.1724 | .8489 |

1- Graduate; 2- Postgraduate; 3- PhD.

The results indicate that the null hypothesis is rejected on the overall basis that the educational qualifications of the teachers have a significant influence on their perceptions of EEG readiness (Table 9.1). Through multiple comparisons (Table 9.2), it was observed that the graduate and postgraduate degree holder teachers had a significant association in their perceptions whereas the other combinations did not have a significant association in their perceptions.

**$H_{6ba}$: Teacher educational qualifications significantly influence teacher perceptions of EEG usefulness.**

Table 9.3: The ANOVA of the EDN of the teacher perceptions of EEG Usefulness

Usefulness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 2.385 | 2 | 1.193 | 2.928 | .037 |
| Within Groups | 49.292 | 121 | .407 | | |
| Total | 51.677 | 123 | | | |

Table 9.4: Multiple Comparison of the EDN of the teacher perceptions of EEG Usefulness

**Multiple Comparisons**

Tukey HSD

| (I) Education | (J) Education | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | .22773 | .13342 | .207 | -.0889 | .5443 |
| | 3.00 | -.19286 | .16183 | .460 | -.5769 | .1911 |
| 2.00 | 1.00 | -.22773 | .13342 | .207 | -.5443 | .0889 |
| | 3.00 | -.42059 | .17986 | .034 | -.8474 | .0062 |
| 3.00 | 1.00 | .19286 | .16183 | .460 | -.1911 | .5769 |
| | 2.00 | .42059 | .17986 | .034 | -.0062 | .8474 |

1- Graduate; 2- Postgraduate; 3- PhD.

The results indicate that the null hypothesis is rejected and that the educational qualifications of the teachers have a significant influence on their perceptions of EEG usefulness (Table 9.3). This implies that to perceive that the EEG usage is beneficial to the students in learning attainment the teacher should have adequate academic qualification. Further, through multiple comparisons (Table 9.4), it was observed that the postgraduate and PhD qualifications combinations of teachers had a significant association in their perceptions, which implies that higher the qualification, better will be the perception of the teachers about EEG usefulness.

**$H_{6ca}$: Teacher educational qualifications significantly influence teacher perceptions of EEG achievement of educational outcomes.**

Table 9.5: The ANOVA of the EDN of teacher perceptions of EEG's Achievement of Educational Outcomes

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 1.782 | 2 | .891 | 2.032 | .04 |
| Within Groups | 53.057 | 121 | .438 | | |
| Total | 54.839 | 123 | | | |

Table 9.6: Multiple Comparison of the EDN of Teacher perceptions of EEG's Achievement of Educational Outcomes

Tukey HSD

| (I) Education | (J) Education | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | .23109 | .13842 | .221 | -.0974 | .5596 |
| | 3.00 | -.10714 | .16789 | .05 | -.5055 | .2913 |
| 2.00 | 1.00 | -.23109 | .13842 | .221 | -.5596 | .0974 |
| | 3.00 | -.33824 | .18660 | .170 | -.7810 | .1046 |
| 3.00 | 1.00 | .10714 | .16789 | .05 | -.2913 | .5055 |
| | 2.00 | .33824 | .18660 | .170 | -.1046 | .7810 |

1- Graduate; 2- Postgraduate; 3- PhD.

The results indicate that the null hypothesis is rejected on the overall basis and that the educational qualifications of the teachers have a significant influence on their perceptions of EEG's achievement of the educational outcomes (Table 9.5). Through multiple comparisons (Table 9.6), it was observed that graduate and PhD qualification combination had a significant association in their perceptions.

### 9.2.2. Influence of teacher age on teacher perceptions of individual-Collective EEG effectiveness

To test the influence of teacher educational qualifications on teacher perceptions of individual-collective EEG's effectiveness, the following hypothesis was tested.

**$H_{7aa}$: Teacher age significantly influences teacher perceptions of individual-collective readiness for EEG**

Table 9.7: The ANOVA of teacher age on teacher perceptions of individual-collective readiness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 1.126 | 2 | .563 | .920 | .401 |
| Within Groups | 73.995 | 121 | .612 | | |
| Total | 75.121 | 123 | | | |

Table 9.8: Multiple Comparison of teacher age on individual-collective readiness

Tukey HSD

| (I) Age | (J) Age | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | -.16795 | .16817 | .579 | -.5670 | .2311 |
| | 3.00 | .19412 | .26143 | .739 | -.4262 | .8145 |
| 2.00 | 1.00 | .16795 | .16817 | .579 | -.2311 | .5670 |
| | 3.00 | .36207 | .28678 | .419 | -.3184 | 1.0426 |
| 3.00 | 1.00 | -.19412 | .26143 | .739 | -.8145 | .4262 |
| | 2.00 | -.36207 | .28678 | .419 | -1.0426 | .3184 |

1- <30 years of age; 2 – 30 to 45 years; 3 - >45 years

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher age does not have a significant influence on their perceptions of individual-collective readiness (Table 9.7). Through multiple comparisons (Table 9.8), it was observed that no two combinations had a significant association in terms of teacher perceptions.

$H_{7ba}$: Teacher age significantly influences teacher perceptions of EEG usefulness.

Table 9.9: The ANOVA of teacher age on teacher perceptions of EEG usefulness

Usefulness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .879 | 2 | .439 | 1.047 | .354 |
| Within Groups | 50.799 | 121 | .420 | | |
| Total | 51.677 | 123 | | | |

Table 9.10: Multiple comparison of teacher aged on teacher perceptions of EEG usefulness

Tukey HSD

| (I) Age | (J) Age | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | -.05314 | .13934 | .923 | -.3838 | .2775 |
| | 3.00 | -.31176 | .21661 | .324 | -.8258 | .2022 |
| 2.00 | 1.00 | .05314 | .13934 | .923 | -.2775 | .3838 |
| | 3.00 | -.25862 | .23761 | .523 | -.8224 | .3052 |
| 3.00 | 1.00 | .31176 | .21661 | .324 | -.2022 | .8258 |
| | 2.00 | .25862 | .23761 | .523 | -.3052 | .8224 |

1- <30 years; 2- 30-45 years; 3- > 45 years.

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher age has no significant influence on teacher perceptions of EEG usefulness (Table 9.9). Through multiple comparisons (Table 9.10), it was observed that no two combinations had a significant association with regard to teacher perceptions.

$H_{7ca}$: Teacher age has a significant influence on teacher perceptions of EEG's achievement of educational outcomes.

Table 9.11: The ANOVA teacher age on teacher perceptions of EEG's achievement of educational outcomes

Achievement

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .822 | 2 | .411 | .921 | .401 |
| Within Groups | 54.016 | 121 | .446 | | |
| Total | 54.839 | 123 | | | |

Table 9.12: A multiple comparison of teacher age on EEG's achievement of educational outcomes

Tukey HSD

| (I) Age | (J) Age | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | -.18256 | .14369 | .415 | -.5235 | .1584 |
| | 3.00 | .05882 | .22337 | .963 | -.4712 | .5889 |
| 2.00 | 1.00 | .18256 | .14369 | .415 | -.1584 | .5235 |
| | 3.00 | .24138 | .24502 | .588 | -.3400 | .8228 |
| 3.00 | 1.00 | -.05882 | .22337 | .963 | -.5889 | .4712 |
| | 2.00 | -.24138 | .24502 | .588 | -.8228 | .3400 |

1- <30 years; 2- 30-45 years; 3- > 45 years.

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher age has no significant influence on their perceptions of EEG's achievement of the educational outcomes (Table 9.11). Through multiple comparisons (Table 9.12), it was observed that no two combinations had a significant association with regard to their perceptions.

### 9.2.3. Influence of teacher gender on teacher perceptions of individual/collective EEG effectiveness

$H_{8aa}$: Teacher gender has a significant influence on teacher perceptions of individual/collective readiness for EEG.

Table 9.13: ANOVA of the Influence of Gender on EEG Readiness

Readiness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .012 | 1 | .012 | .020 | .887 |
| Within Groups | 75.109 | 122 | .616 | | |
| Total | 75.121 | 123 | | | |

*As there are only two groups for comparison, multiple comparison is impossible.

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher gender has no significant influence on teacher perceptions of individual-collective EEG readiness (Table 9.13).

$H_{8ba}$: Teacher gender has a significant influence on teacher perceptions of EEG Usefulness.

Table 9.14: ANOVA of the Influence of Gender on EEG Usefulness Perception

Usefulness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .338 | 1 | .338 | .804 | .372 |
| Within Groups | 51.339 | 122 | .421 | | |
| Total | 51.677 | 123 | | | |

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher gender has no significant influence on teacher perceptions of EEG usefulness (Table 9.14).

$H_{8ca}$: There is a significant influence of the gender of the teachers on the EEG achievement of educational outcomes.

Table 9.15: ANOVA of the Influence of Gender on EEG Achievement of Educational Outcomes

Achievement

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .371 | 1 | .371 | .830 | .364 |
| Within Groups | 54.468 | 122 | .446 | | |
| Total | 54.839 | 123 | | | |

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher gender has no significant influence on EEG's achievement of the educational outcomes (Table 9.15).

### 9.2.4. Influence of Designation of the Teachers on Individual-Collective EEG Effectiveness Perceptions

$H_{9aa}$: There is a significant influence of Designation of the teachers on the Individual-collective readiness to EEG.

Designation is the rank the teachers hold in the schools (e.g. Class teacher; School Principal; Programme Director) and it may vary based on the governance of the schools, and the perception about the individual and collective usage of EEG could vary based on these designations.

Table 9.16: Influence of Designation on EEG Readiness

Readiness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 1.522 | 2 | .761 | 1.253 | .289 |
| Within Groups | 74.110 | 122 | .607 | | |
| Total | 75.632 | 124 | | | |

Table 9.17: Multiple Comparison of the Influence of designation on EEG Readiness

Readiness
Tukey HSD

| (I) Designation | (J) Designation | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|
| 1.00 | 2.00 | -.33010 | .20944 | .260 | -.8270 | .1668 |
| | 3.00 | .00324 | .32732 | 1.000 | -.7734 | .7799 |
| 2.00 | 1.00 | .33010 | .20944 | .260 | -.1668 | .8270 |
| | 3.00 | .33333 | .37311 | .645 | -.5519 | 1.2186 |
| 3.00 | 1.00 | -.00324 | .32732 | 1.000 | -.7799 | .7734 |
| | 2.00 | -.33333 | .37311 | .645 | -1.2186 | .5519 |

1 – Class teacher; 2- School Principal; 3- Programme Director

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher designation has no significant influence on teacher perceptions of EEG readiness (Table

9.16). Through multiple comparisons (Table 9.17), it was observed that no two combinations had a significant association in their perceptions.

$H_{9ba}$: There is a significant influence of Designation of the teachers on the usefulness perception of EEG.

Table 9.18: The ANOVA of the influence of designation on Usefulness Perception of EEG

Usefulness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .116 | 2 | .058 | .134 | .875 |
| Within Groups | 53.052 | 122 | .435 | | |
| Total | 53.168 | 124 | | | |

Table 9.19: Multiple Comparison of the influence of Designation on Usefulness Perception of EEG

Usefulness
Tukey HSD

| (I) Designation | (J) Designation | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | -.04612 | .17720 | .963 | -.4666 | .3743 |
| | 3.00 | -.12945 | .27694 | .887 | -.7865 | .5276 |
| 2.00 | 1.00 | .04612 | .17720 | .963 | -.3743 | .4666 |
| | 3.00 | -.08333 | .31568 | .962 | -.8323 | .6657 |
| 3.00 | 1.00 | .12945 | .27694 | .887 | -.5276 | .7865 |
| | 2.00 | .08333 | .31568 | .962 | -.6657 | .8323 |

1- 1 – Class teacher; 2- School Principal; 3- Programme Director

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher designation does not have a significant influence on teacher perceptions of EEG usefulness (Table 9.18). Through multiple comparisons (Table 9.19), it was observed that no two combinations had a significant association in their perceptions.

$H_{9ca}$: There is a significant influence of Designation of the teachers on the EEG achievement of educational outcomes.

Table 9.20: ANOVA of influence of Designation of Teachers on EEG Achievement

Achievement

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .362 | 2 | .181 | .402 | .670 |
| Within Groups | 54.477 | 121 | .450 | | |
| Total | 54.839 | 123 | | | |

Table 9.21: Multiple Comparison of influence of Designation of Teachers on EEG Achievement

Achievement
Tukey HSD

| (I) Designation | (J) Designation | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | .02574 | .18042 | .989 | -.4024 | .4539 |
| | 3.00 | -.24510 | .28187 | .660 | -.9139 | .4238 |
| 2.00 | 1.00 | -.02574 | .18042 | .989 | -.4539 | .4024 |
| | 3.00 | -.27083 | .32121 | .677 | -1.0330 | .4914 |
| 3.00 | 1.00 | .24510 | .28187 | .660 | -.4238 | .9139 |
| | 2.00 | .27083 | .32121 | .677 | -.4914 | 1.0330 |

1 – Class teacher; 2- School Principal; 3- Programme Director

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher designation has no significant influence on EEG achievement perception (Table 9.20). Through multiple comparisons (Table 9.21), it was observed that no two combinations had a significant association in their perceptions.

### 9.2.5. Influence of Experience of the Teachers on Individual-Collective EEG Effectiveness Perceptions

$H_{10aa}$: There is a significant influence of experience of the teachers on the EEG readiness.

Table 9.22: ANOVA of influence of Influence of Experience on EEG Readiness

Readiness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .992 | 2 | .496 | .810 | .447 |
| Within Groups | 74.129 | 121 | .613 | | |
| Total | 75.121 | 123 | | | |

Table 9.23: Multiple Comparison of influence of Experience on EEG Readiness

Tukey HSD

| (I) Experience | (J) Experience | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | -.18950 | .15159 | .426 | -.5492 | .1702 |
| | 3.00 | -.13394 | .27652 | .879 | -.7901 | .5222 |
| 2.00 | 1.00 | .18950 | .15159 | .426 | -.1702 | .5492 |
| | 3.00 | .05556 | .28750 | .980 | -.6267 | .7378 |
| 3.00 | 1.00 | .13394 | .27652 | .879 | -.5222 | .7901 |
| | 2.00 | -.05556 | .28750 | .980 | -.7378 | .6267 |

1- < 5 years; 2- 5 – 10 years; 3- > 10 years.

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher experience has no significant influence on teacher perceptions of EEG readiness (Table 9.22). Through multiple comparisons (Table 9.23), it was observed that no two combinations had a significant association in their perceptions.

$H_{10ba}$: There is a significant influence of experience of the teachers on the perceived EEG usefulness.

Table 9.24: ANOVA of influence of Experience on EEG Usefulness

Usefulness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .751 | 2 | .375 | .892 | .413 |
| Within Groups | 50.927 | 121 | .421 | | |
| Total | 51.677 | 123 | | | |

Table 9.25: Multiple Comparison of influence of Experience on EEG Usefulness

Usefulness
Tukey HSD

| (I) Designation | (J) Designation | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | .10372 | .12564 | .688 | -.1944 | .4019 |
| | 3.00 | -.19787 | .22919 | .664 | -.7417 | .3460 |
| 2.00 | 1.00 | -.10372 | .12564 | .688 | -.4019 | .1944 |
| | 3.00 | -.30159 | .23830 | .417 | -.8670 | .2639 |
| 3.00 | 1.00 | .19787 | .22919 | .664 | -.3460 | .7417 |
| | 2.00 | .30159 | .23830 | .417 | -.2639 | .8670 |

1- < 5 years; 2- 5 – 10 years; 3- > 10 years.

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher experience has no significant influence on teacher perceptions of EEG usefulness (Table 9.24). Through multiple comparisons (Table 9.25), it was observed that no two combinations had a significant association in their perceptions.

$H_{10ca}$: There is a significant influence of experience of the teachers on the perceived EEG achievement.

Table 9.26: ANOVA of Influence of Experience on EEG Achievement Perception

Achievement

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .520 | 2 | .260 | .579 | .562 |
| Within Groups | 54.319 | 121 | .449 | | |
| Total | 54.839 | 123 | | | |

Table 9.27: Multiple Comparison of influence of Experience on EEG Achievement Perception

Tukey HSD

| (I) Experience | (J) Experience | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | .12688 | .12976 | .592 | -.1810 | .4348 |
| | 3.00 | .15068 | .23670 | .800 | -.4110 | .7124 |
| 2.00 | 1.00 | -.12688 | .12976 | .592 | -.4348 | .1810 |
| | 3.00 | .02381 | .24611 | .995 | -.5602 | .6078 |
| 3.00 | 1.00 | -.15068 | .23670 | .800 | -.7124 | .4110 |
| | 2.00 | -.02381 | .24611 | .995 | -.6078 | .5602 |

1- < 5 years; 2- 5 – 10 years; 3- > 10 years.

The results indicate that the null hypothesis cannot be rejected on the overall basis and that teacher experience has no significant influence on teacher perception of EEG achievement (Table 9.26). Through multiple comparisons (Table 9.27), it was observed that no two combinations had a significant association in their perceptions.

### 9.2.6. Influence of Course Taught by the Teachers on Individual-Collective EEG Effectiveness Perceptions

$H_{11aa}$: There is a significant influence of course taught by the teachers on the EEG readiness.

Table 9.28: ANOVA of influence of Course Taught on EEG Readiness Perception

Readiness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .992 | 2 | .496 | .810 | .447 |
| Within Groups | 74.129 | 121 | .613 | | |
| Total | 75.121 | 123 | | | |

Table 9.29: Multiple Comparison of Course Taught on EEG Readiness Perception

Tukey HSD

| | | Mean | | | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| (I) Course | (J) Course | Difference (I-J) | Std. Error | Sig. | Lower Bound | Upper Bound |
| 1.00 | 2.00 | -.18950 | .15159 | .426 | -.5492 | .1702 |
| | 3.00 | -.13394 | .27652 | .879 | -.7901 | .5222 |
| 2.00 | 1.00 | .18950 | .15159 | .426 | -.1702 | .5492 |
| | 3.00 | .05556 | .28750 | .980 | -.6267 | .7378 |
| 3.00 | 1.00 | .13394 | .27652 | .879 | -.5222 | .7901 |
| | 2.00 | -.05556 | .28750 | .980 | -.7378 | .6267 |

1- Mathematics; 2- General Science; 3- Others.

The results indicate that the null hypothesis cannot be rejected on the overall basis and the course taught by the teachers has no significant influence on EEG readiness perception (Table 9.28). Through multiple comparisons (Table 9.29) it was observed that no two combinations had a significant association in their perceptions.

$H_{11ba}$: There is a significant influence of course taught by the teachers on the EEG usefulness perception.

Table 9.30: ANOVA of influence of Course Taught on EEG Usefulness Perception

Usefulness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .751 | 2 | .375 | .892 | .413 |
| Within Groups | 50.927 | 121 | .421 | | |
| Total | 51.677 | 123 | | | |

The results indicate that the null hypothesis cannot be rejected on the overall basis and the course taught by the teachers has no significant influence on EEG usefulness perception (Table 9.30). Through multiple comparisons (Table 9.31) it was observed that no two combinations had a significant association in their perceptions.

Table 9.31: Multiple Comparison of influence of Course Taught on EEG Usefulness Perception

Tukey HSD

| (I) Course | (J) Course | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|
| 1.00 | 2.00 | .10372 | .12564 | .688 | -.1944 | .4019 |
| | 3.00 | -.19787 | .22919 | .664 | -.7417 | .3460 |
| 2.00 | 1.00 | -.10372 | .12564 | .688 | -.4019 | .1944 |
| | 3.00 | -.30159 | .23830 | .417 | -.8670 | .2639 |
| 3.00 | 1.00 | .19787 | .22919 | .664 | -.3460 | .7417 |
| | 2.00 | .30159 | .23830 | .417 | -.2639 | .8670 |

1- Mathematics; 2- General Science; 3- Others.

$H_{11bc}$: The course taught by the teachers has a significant influence on EEG's achievement of the educational outcomes.

Table 9.32: ANOVA of influence of Course Taught on Achievement

Achievement

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .520 | 2 | .260 | .579 | .562 |
| Within Groups | 54.319 | 121 | .449 | | |
| Total | 54.839 | 123 | | | |

Table 9.33 Multiple Comparison of Influence of Course Taught on Achievement

Tukey HSD

| (I) Course | (J) Course | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | .12688 | .12976 | .592 | -.1810 | .4348 |
| | 3.00 | .15068 | .23670 | .800 | -.4110 | .7124 |
| 2.00 | 1.00 | -.12688 | .12976 | .592 | -.4348 | .1810 |
| | 3.00 | .02381 | .24611 | .995 | -.5602 | .6078 |
| 3.00 | 1.00 | -.15068 | .23670 | .800 | -.7124 | .4110 |
| | 2.00 | -.02381 | .24611 | .995 | -.6078 | .5602 |

1- Mathematics; 2- General Science; 3- Others.

The results indicate that the null hypothesis cannot be rejected on the overall basis and the course taught by the teachers has no significant influence on EEG achievement perception (Table 9.32). Through multiple comparisons (Table 9.33) it was observed that no two combinations had a significant association in their perceptions.

### 9.2.7. Influence of Type of Game used by the Teachers on Individual-Collective EEG Effectiveness Perceptions

$H_{12aa}$: There is a significant influence of type of the game used by teachers on the Individual-collective readiness to EEG.

Table 9.34: The ANOVA of Influence of type of the game Individual-collective Readiness to EEG

Readiness

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 3.570 | 2 | 1.785 | 3.018 | .048 |
| Within Groups | 71.551 | 121 | .591 | | |
| Total | 75.121 | 123 | | | |

Table 9.35: The Multiple Comparison of influence of Type of the Game on Individual-collective Readiness to EEG

Tukey HSD

| (I) Training | (J) Training | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|
| 1.00 | 2.00 | -.22869 | .19645 | .477 | -.6949 | .2375 |
| | 3.00 | -1.00647 | .45039 | .038 | -2.0752 | .0623 |
| 2.00 | 1.00 | .22869 | .19645 | .477 | -.2375 | .6949 |
| | 3.00 | -.77778 | .47954 | .240 | -1.9157 | .3601 |
| 3.00 | 1.00 | 1.00647 | .45039 | .038 | -.0623 | 2.0752 |
| | 2.00 | .77778 | .47954 | .240 | -.3601 | 1.9157 |

1- Battery-operated games; 2- Software-based games; 3- Others.

The results indicate that the null hypothesis is rejected on the overall basis and the type of the game used by the teachers has a significant influence on EEG readiness perception (Table 9.34). Through multiple comparisons (Table 9.35), it was observed that battery-operated games and all the other types of electronic game (other than computer software) combinations had a significant association in their perceptions.

$H_{12ba}$: There is a significant influence of type of the game used by teachers on the EEG usefulness perception.

Table 9.36: The ANOVA of Influence of Type of the Game on the EEG Usefulness Perception

Readiness

| | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 3.570 | 2 | 1.785 | 3.018 | .049 |
| Within Groups | 71.551 | 121 | .591 | | |
| Total | 75.121 | 123 | | | |

Table 9.37: A multiple comparison of influence of Type of the Game on the EEG Usefulness Perception

Tukey HSD

| (I) Type | (J) Type | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | -.22869 | .19645 | .477 | -.6949 | .2375 |
| | 3.00 | -1.00647 | .45039 | .038 | -.0221 | .0623 |
| 2.00 | 1.00 | .22869 | .19645 | .477 | -.2375 | .6949 |
| | 3.00 | -.77778 | .47954 | .240 | -1.9157 | .3601 |
| 3.00 | 1.00 | 1.00647 | .45039 | .038 | -.0221 | 2.0752 |
| | 2.00 | .77778 | .47954 | .240 | -.3601 | 1.9157 |

1- Battery-operated games; 2- Software-based games; 3- Others.

The results indicate that the null hypothesis is rejected on the overall basis and the type of the game used by the teachers has a significant influence on EEG usefulness perception (Table 9.36). Through multiple comparisons (Table 9.37), it was observed that battery-operated games and all the other types of electronic game (other than computer software) combinations had a significant association in their perceptions.

$H_{12ca}$: There is a significant influence of type of the game used by teachers on the EEG achievement of educational outcomes.

Table 9.38: The ANOVA of influence of Type of the Game on the EEG Achievement of Educational Outcomes

Achievement

| | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 4.299 | 2 | 2.149 | 3.236 | .043 |
| Within Groups | 80.371 | 121 | .664 | | |
| Total | 84.669 | 123 | | | |

Table 9.39: Multiple Comparison of Type of the Game on the EEG Achievement of Educational Outcomes

Tukey HSD

| (I) Training | (J) Training | Mean Difference (I-J) | Std. Error | Sig. | 95percent Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1.00 | 2.00 | -.26052 | .20821 | .426 | -.7546 | .2335 |
| | 3.00 | -1.09385 | .47734 | .031 | -2.2265 | .0388 |
| 2.00 | 1.00 | .26052 | .20821 | .426 | -.2335 | .7546 |
| | 3.00 | -.83333 | .50824 | .233 | -2.0393 | .3727 |
| 3.00 | 1.00 | 1.09385 | .47734 | .031 | -.0388 | 2.2265 |
| | 2.00 | .83333 | .50824 | .233 | -.3727 | 2.0393 |

1- Battery-operated games; 2- Software-based games; 3- Others.

The results indicate that the null hypothesis is rejected on the overall basis and that the type of game used by the teachers has a significant influence on teacher perceptions of EEG's achievement of the educational outcomes (Table 9.38). Through multiple comparisons (Table 9.39), it was observed that battery-operated games and all the other types of electronic game (other than computer software) combinations had a significant association in the perceptions of the teachers. There is a possibility that the teachers were more familiar with battery operated games in comparison to other forms of EEG such as computer based and hence this type of gaming has been dominated.

### 9.3. Conclusions

This chapter has recorded the findings on the effect of teacher characteristics on their perceptions about EEG in the individual and collective mode of teaching. It was found that, in general, teacher characteristics have a significant influence on their perceptions of individual and collective EEG usage.

It was found that the educational qualifications of the teachers have a significant influence on their perceptions of EEG readiness. Specifically, graduate and postgraduate degree holder teachers perceived there to be significant associations whereas the other combinations did not. Teacher educational qualifications have a significant influence on teacher perceptions of EEG usefulness and postgraduate and PhD qualifications combinations of teachers had a significant association in their perceptions. Teacher educational qualifications have a significant influence on their perceptions of EEG's achievement of the educational outcomes and graduate and PhD qualification combinations had a significant association in their perceptions. It can be concluded that, in terms of the categories of the qualifications, there is no common consensus among the teachers. It can also be concluded that the authorities of primary education must give due importance to teacher qualifications as these have a bearing on their perceptions about EEG's success in primary education.

Teacher age has no significant influence on teacher perceptions of individual-collective readiness, EEG usefulness, and EEG achievement of the educational outcomes. Further, no two combinations of teacher age group had a significant association in terms of teacher perceptions. On the overall basis, teacher gender has no significant influence on teacher perceptions of individual-collective EEG readiness, EEG usefulness, and EEG achievement of the educational outcomes. The conclusion that can be drawn is that, irrespective of their age, the faculty can be recruited to indulge in EEG-based teaching.

The designation of the teachers has no significant influence on their perceptions of EEG readiness, the perceived usefulness of EEG, and the perceived achievement and it was found that no two combinations had a significant association in their perceptions. Again, the designation held by the teachers and the cadres in which they operate has no bearing on their perceptions about EEG-based teaching so, irrespective of the designation held by the teachers in the school, EEG implementation may be undertaken.

Teacher experience does not have a significant influence on teacher perceptions of EEG readiness, EEG usefulness, and EEG achievement, and also no two combinations had a significant association in their perceptions. This is an important finding through which it can be concluded that both junior and senior teachers can be equally adopted in EEG based teaching in schools.

The course taught by the teachers has no significant influence on EEG readiness perception, EEG usefulness perception, and EEG achievement perception, and also no two combinations had a significant association in their perceptions. During the discussions with the teachers, some doubted the usefulness of EEG usage for some specific courses and the teacher background in teaching some courses. It can be clearly concluded that, irrespective of the courses taught by the teachers, they perceive EEG to be equally effective.

The type of games used by the teachers has a significant influence on EEG readiness perception, EEG usefulness perception, and the perception of EEG achievement, and also the teacher perceptions about battery-operated games and all the other types of electronic game (other than computer software) had a significant association. This is an important point to note. The teachers are very particular about the type of the games used for EEG-based education. Hence, there is a need to select the games which the teachers find to be the most appropriate for teaching a particular topic on a course.

In general, the findings of this chapter lead to a general conclusion that teacher characteristics have some influence on their perceptions about the usage of EEG in primary school for educational purposes. While it is necessary to consider some of the teacher characteristics if the school is particular about promoting the EEG, it is not important to consider some of the characteristics. This chapter has highlighted those specific teacher characteristics which may have to be considered by the management of the primary schools during the teacher selection if they are particular about the EEG implementation.

# CHAPTER 10

# Findings: Qualitative Research

## 10.1. Introduction

The aim of the research has been to assess the impact of Educational Electronic Games (EEG) on mathematics learning in primary school when learning takes place via the individual and collective modes and to make suggestions to enhance learning effectiveness. Collecting the qualitative primary data and information through a questionnaire survey and semi-structured interviews with the teachers who had direct experience of using EEG in the individual and collective modes was the recommended method. This chapter records the findings obtained through employing these two qualitative methods. The conclusions reached based on the qualitative data are provided at the end of the chapter.

## 10.2. Questionnaire survey

The primary data collected through the questionnaire survey was both qualitative and quantitative in nature. The qualitative response of the teachers was of particular importance to this research as their observations of learning through EEG in general and mathematics in particular was important to this research. The second objective of this research was to assess the impact of EEG on learning mathematics and the qualitative observation of the teachers on this issue was of significance to this research. Specific questions were put to the respondents to answer in qualitative terms to improve the effectiveness of EEG-based learning. Having seen the impact of EEG-based learning in their school, the teachers offered several valuable suggestions to improve the individual learning through EEG in response to the open-ended qualitative questions. In this section, their suggestions are collated and presented in generic terms rather than in the form of individual views and opinions. Their responses to individual questions will be analysed in the following paragraphs.

*What are your specific suggestions about improving the individual learning of the students?*

The respondents stated that the students should be given the ‘ownership’ of knowledge accumulation rather than giving them a given set of rules and procedures to follow. They should be able to choose their topic from a given set of topics on a individual basis and to play

EEG to achieve the outcome without being guided to work on specific problems given by their teachers. This kind of freedom enables them to choose from among several alternatives, which would make them feel free and they would enjoy learning in a natural setting rather than in a guided manner where the students simply follow instructions. The teachers must be aware that there are students with different learning ability in terms of speed, depth of understanding, and knowledge base. While fast learning does not ensure the ability to retain the knowledge for a longer duration, slow learning does not mean a lack of concentration. The teachers will have to deal with the students with this understanding and permit them to enjoy the EEG experience rather than making it another classroom-based assignment.

Some of the teachers subscribed to the view that learning is basically an individual characteristic of a learner and opine that the emphasis must be on individual learning with the acquisition perspective as given by Nafukho et al. (2004). At the same time, some teachers consider learning as a group activity and it takes place through group interaction (Davis, 1999). After a detailed discussion, the teachers preferred collective learning over individual learning and their points in support of this argument were that it would provide a social set-up for learning, make learning a natural process, that learning will be considered an interesting exercise to participate than when work is imposed on an individual, it makes the process interesting, the human interaction will be stimulating, and that ideas multiply in groups and knowledge creation takes place.

Many of the teachers stated that the success or failure of EEG usage as a tool depends to a considerable extent on the type of game chosen. Various types of games are available in the form of mazes, puzzles, quizzes, fantasy, adventure, and so on. The students in 5$^{th}$ grade will be more attracted to the type of the activity, fun element and the entertainment than the educational value of the game. So, careful choosing the games was considered to be one of the most important aspects which influence the success of the EEG in achieving the educational outcomes. This point was also supported through the hypothesis testing. Thus, the school authorities must be careful when choosing the type of the games used for EEG as they have a significant influence on the educational outcomes they produce.

One more suggestion that emerged out was that the students should be trained in the 21st century skills of learning through EEG-based exercises rather than simply the drills and practice which measure knowledge and skills enhancement with no attitude component attached. This required a keen observation of the student to facilitate learning which suits that particular type of student. While problem-solving, creativity, data management and information gathering were important as a learning process, the transformational tools to make the student a lifelong learner were also equally important, and sensitization to social issues was also expected to be a part of learning process. So, whenever possible, the examples and problem situations could be chosen in the social or cultural contexts so that the students develop a strong sense of belonging to the society and become responsible global citizens.

*What are your specific suggestions about improving the collective learning of the students?*

The respondents indicated that collective learning is different from conventional learning in the sense that it conflicts with the belief that a subject has to be studied in isolation from other learners. They stated that it gives a social dimension to learning which is essential in the present globalized scenario. The respondents were of the opinion that learning cannot be restricted to the classroom and be considered an interaction between the teacher and the students, but should be extended to become the social interaction between the learners. According to the teachers (respondents), learning was multi-dimensional and had dimensions including the inculcation of the art of living together with the development of the ability to: communicate with confidence and clarity, resolve conflicts, express cultural sensitivity, and team spirit; the dimension of doing things professionally: problem-solving skills, the capacity to act wisely, and the ability to apply the knowledge acquired as and when required; the dimension of knowing: the theoretical foundation, comprehension, and ability to research; and finally the dimension of 'being': developing high self-esteem, building emotional intelligence, and cultural sensitivity. The teachers stated that these dimensions can be incorporated into learning only through collective learning. They emphasized the co-creation of knowledge by all those who are involved in the teaching/learning process.

Some of the teachers opined that learning is basically the practice-based construction of knowledge and that collective learning is more appropriate for the construction of new knowledge. The teachers viewed collective gaming as a means of individual collective reflection of thoughts and exchange of views which support as well as contrast and take the learner through a path of progressive learning that is characterized by dialogue, critical reflection, and the inquiry-based acquisition of knowledge. This view is in alignment with the earlier research by Gherardi (2000) and Hager (2004). Here, learning is viewed more as relational knowledge production rather than the individual acquisition of information and its transformation into knowledge. Teachers have also expressed that individual learning has the disadvantage that the new information which the student receives will be subjected to only one line of questioning by a student, whereas in collective learning through EEG, each student will benefit from the multiple perspectives of the students and the different line of questioning by different students with a diversified background.

*Do you find EEG useful in teaching/learning? If so why? If not, why not?*

There was a mixed reaction to this question. While some of the teachers found EEG very useful, others felt that it can only supplement conventional teaching but can never ever be a stand-alone mode of learning. Those who endorsed the usage of EEG claimed that the entertainment value of the game would make the student attracted to learning. They also opined that EEG had the ability to keep the students engaged irrespective of whether the individual or collective mode of learning was employed. These views are in tune with the practice-based and participative mode of learning through EEG by Gherardi (2000) and Hager (2004). Many teachers have stated that the very fact that EEG gives a sense of ownership to learning, puts the students in the driver's seat and keeps them engaged throughout so that they can build upon the knowledge. EEG in its very nature has the ability to reduce the reaction time, as stated by some of the teachers. Several other teachers stated that it would improve hand/eye coordination. The teachers also stated that, as the students record their own progress, this builds their self-esteem. There were other observations by the teachers that EEG is beneficial to the students as it has a fun element attached to it, inbuilt curiosity which grabs their attention, and above all entertainment value, which makes the student work at EEG for longer. The teachers also associated other benefits with it, such as EEG would make them techno-savvy, it can help the students to overcome techno-phobia and the gender imbalance and may enable them to develop transferable, technology-based skills. The teachers also stated that they have observed that students who started as very slow users of EEG have managed to develop tremendous speed in learning through EEG in a very short span of time. The general opinion of the teachers was that EEG can positively influence the cognitive, social, and moral attitudes of the learners, and also make them more creative and independent. All of these observations by the teachers are in concurrence with the earlier researches on EEG (Wright, 2001, Koc, 2005, Zavaleta at al., 2005).

Another set of teachers stated that EEG can be a very good educational tool as it can be used to assess several competencies of the students. First of all, EEG provides a means for continuous assessment as and when the student makes progress in the given topic. EEG can be used to assess the participation of a student with his/her classmates. It can be used to measure performance and a set of skills including communication skills, spatial skills, self-esteem, goal-setting, self-concept, assertiveness, knowledge-seeking behaviour, knowledge dissemination ability, and team work.

Some teachers also mentioned the ill effects of EEG, which includes increased aggressiveness and various medical and psychosocial effects. Some earlier researches also brought out the negative influence of EEG (Griffiths, 2002). However, the teachers agreed that these ill effects occurred only when EEG usage exceeded the recommended value.

*How do you think EEG has contributed specifically to the learning of Mathematics?*

This question is of particular significance to this research as the entire study on the effectiveness of individual and collective EEG is based on mathematics. So, its relevance in education in terms of mathematics is of particular interest to this study. The teachers stated that EEG has the potential to enhance the mathematics learning skills of the students by leap and bounds. The teachers identified that EEG can contribute to the learning of specific mathematical skills, such as: numerical calculations, algebraic manipulation, spatial visualization, data analysis, measurement, the use of mathematic operators, estimation, etc.

They expressed that it could also be used to teach some of the mathematical concepts in Numerical calculations, Algebra, Geometry, Statistics, and Probability. Some teachers expressed that learning mathematics is a systematic logical process which is sequential and EEG can facilitate the learner in mastering the ingredients of this in the form of reasoning, communication, thinking and heuristics, and modelling skills. They expressed that a subject like mathematics demanded metacognition and that EEG could support this through monitoring one's independent thinking and self-regulation in thinking. Finally, the teachers also identified that the right kind of attitudes were required in gaining mastery in mathematics and that EEG had the ability to alter the students' beliefs, interests, appreciation, confidence and perseverance.

The teachers offered made important revelations which are significant to this study. One of their major challenges in the class was to compensate for the individual differences between the students while learning mathematics. In their experience, it was almost impossible to deliver classes which would meet the specific needs of every individual student in terms of his/her ability to learn at a particular pace or at a given depth of understanding. What they meant was if they go slow in their teaching, the slow learners would be comfortable but quick learners would become bored, and if they repeat the same sentences to make the subject more understandable, the slow learners would appreciate this but the fast learners would become bored. Similarly, if they try to teach at a higher level of understanding, attempting to give an in-depth knowledge of the subject, the more intelligent students would appreciate this but the less intelligent students might lose interest. So, managing this kind of heterogeneity in student learning was a challenge, as expressed by the teachers, which was addressed very well by EEG-based learning. As there are levels of increasing order of difficulty, the student can proceed from one level to the other at his own pace. There is a lot of flexibility in learning as those students who have successfully gone through all the levels and very well comprehended the topic can assist others' learning. As assessment has been inbuilt as a part of learning so that the students can learn at their own pace.

EEG has contributed to learning as it combines the social skills of the learner with the knowledge and skills associated with learning. The teachers stated that EEG would be more effective when used in a collective mode rather than an individual mode. They felt that the individual mode of EEG is very important because the student has to acquire knowledge by him/herself no matter however much he/she interacts with the surroundings, but, it is important to spend more time on the collective mode as learning is a social phenomenon and the students learn much more in a group than in isolation as it is easier to ask about their doubts and clarify them in their peer-group than with the teacher. Moreover, they can discuss even the silliest of their doubts with the peer group and get them clarified whereas they may not have that liberty with the teacher.

### 10.3. Semi-structured Interviews

One more primary qualitative data collection process in this research was using the semi-structured interviews with the 'key informants'. Two semi-structured interviews have been conducted: one was with an experienced teacher and the other with the Principal (Appendix 8). Both respondents had a background in Educational Psychology and Educational Technology with considerable teaching experience of mathematics and training experience in educational technologies and curriculum development.

The protocol used for the semi-structured interview is attached in Appendix 2. The interviewees have given very valuable inputs and some insight gaining experience in connection to the individual-collective EEG. The open-ended questions enabled them to elaborate on their views of EEG. The outcome of the interviews not only endorsed the findings through hypothesis testing, but also provided explanations about the causation between the variables of interest. The interviewees agreed that EEG has the potential to enhance learning in both the individual and collective modes (Hypothesis 1).

They stated that EEG also has the potential to make the knowledge acquired relatively more permanent in comparison to the traditional classroom teaching using the blackboard and power-point or multi-media based presentations (Hypothesis 2). The interviewees observed that the students mixed freely, irrespective of gender, to solve the problems while in the collective mode of EEG and were also equally interested and kept themselves engaged during the individual mode of EEG so there cannot be any difference between their learning and outcome achievement (Hypothesis 3). The interviewees also observed that, regarding the kind of interaction which has taken place between the students, irrespective of their gender, the permanency of the acquired knowledge can also be uniform across the genders (Hypothesis 4).

The purpose of the semi-structured interviews was not to confirm the results of hypothesis testing but to assess qualitatively the impact of EEG as observed by the teachers who had experience of the implementation of EEG. Both interviewees were relatively positive about the academic value of EEG, both in individual and collective form. They highlighted the observations which demonstrate student participation. Enhancing the curiosity of the student was, according to them, an inbuilt feature of EEG. They also endorsed the fun element and entertainment value of EEG, which made the tool very effective in achieving the outcomes. The interviewees were very confident about the fact that the collective mode of EEG had a better impact on the achievement of the educational outcomes. They were of the opinion that learning in a classroom should exceed mere knowledge assimilation and should cover every aspect which make students responsible citizens with cultural sensitivity, social awareness and environmental awareness. They stated that the collective mode of EEG would provide them with an opportunity to go beyond the syllabus and make the students interact in an open environment with all the aspects related to the topic and undergo overall development. The interviewees also reflected their stand on the gender difference issue. Both male and female students would respond equally well to the EEG mode of learning and achieve the educational outcomes as well as retain knowledge for a longer time duration without any gender difference.

### 10.4. Conclusions

Qualitative data were collected through the respondents, who were the primary school teachers. The data collection was a questionnaire survey and two semi-structured interviews. In the survey, there were four specific questions which were directly connected to the objectives of the research. In response to the first question on suggestions about improving the individual learning of the students, the teachers suggested the following methods. The students should be given 'ownership' over their learning. They should be permitted to choose a topic in the given section through their individual choices in EEG. The freedom of choice will make the students feel comfortable and at ease. At the same time, they will learn some principles of decision-making as they will learn by themselves how their choices support or hinder their learning objectives. The teachers must be made knowledgeable enough to know that the students naturally vary with their ability to cope with the speed and depth of understanding. The teachers were of the opinion that a good EEG must support all of the different categories of student, including slow and fast learners with different levels of knowledge and experience and promote learning in them all.

When the individual and collective modes of learning were discussed, the teachers preferred the collective mode of learning. The teachers were of the opinion that the type of EEG chosen was an important determinant of the success of EEG. The fun element and entertainment component were preferred to be a part of the EEG as the teachers felt that children enjoy these. The teachers suggested that the school authorities should carefully choose the type of EEG as it has a bearing on the educational outcome achievement. The teachers felt that learning a topic through a gadget is important on the part of a student, but at the same time the teachers have the responsibility of making the students lifelong learners and they conveyed that EEG must be able to create interest among students in the topic to promote further learning in addition to making the subject more comprehensive.

In terms of collective learning, the teachers expressed that it breaks the myth that learning is an activity to be carried out in isolation by a student. The teachers considered the very process of learning to be a multidimensional activity that is associated with the inculcation of several abilities and skills which cannot take place in isolation but will be possible only in the collective mode when they interact with other students. The practice-based construction process of knowledge was one view which emerged, as per their response to the qualitative questions.

With reference to the question on the usefulness of EEG as an aid to teaching mathematics, there was a mixed response by the teachers. The conclusion that can be drawn based on the responses of the teachers is that EEG can be a good supplement to teaching but cannot be a standalone tool for teaching. The teachers concur in their views about the entertainment value of EEG and its ability to keep them engaged throughout the process. The teachers are of the opinion that hand/eye coordination will improve through EEG as an add-on and also make the students independent learners. It can be concluded that the students' self-esteem also builds up as they can act independently while using the collective mode of EEG.

Speaking in terms of the unique contribution to the learning of mathematics, the teachers agree that EEG has the ability to make mathematics learning far easier compared to conventional methods. They were of the opinion that it is of particular use in learning specific mathematical skills, such as estimation, analysis and measurement. The teachers have found that EEG has the potential to provide conceptual clarity to the students and improve meta-cognition. Most of the teachers stated that EEG would enhance the social skills of the students. Attitude building of the students towards mathematics was also listed as one of the benefits. The important contribution that EEG can make, as expressed by the teachers, is that it would handle the heterogeneity of the class in terms of intelligence, background, attitude, gender difference, speed of learning etc., much better than conventional teaching methods. Finally, the general conclusion that can be drawn based on the qualitative input of the teachers is that both the individual and collective modes of learning through EEG are useful in learning mathematics.

The semi-structured interviews have provided the qualitative inputs for the justification of the results obtained through hypothesis testing and also provided some insightful experiences of the teachers regarding EEG usage in learning mathematics in the context of primary education. First of all, the conclusion through hypothesis testing that EEG has the potential to enhance learning in both the individual and collective modes stands was supported by both interviewees. The teachers conveyed that it is the switch over from the teacher-centric teaching to the learner-centric learning mode in both individual and collective modes of EEG-based learning that makes learning more enjoyable, gives a sense of ownership, satisfies the individual's needs, suits the individual's speed and intellectual ability, promotes group learning, takes them through the process more systematically and in a structured manner, eliminates human error in teaching, offers challenges and promotes a competitive spirit, makes learning fun and entertaining through the usage of media, and, thus, makes learning a pleasurable activity for the student. Further, the self-assessment enables the students to obtain feedback on their performance on the spot and immediately guides them to the right answers as well as provides the approach to the right answers, which will surely enhance learning.

The teachers agreed to the point that EEG, in both the individual and collective mode, has the ability to improve the permanency of learning mathematics. The teachers observed that students have a natural ability to recall pictures, diagrams and graphics with sound with far higher accuracy and over a longer period of time after learning in comparison to what they see or hear from the instructions issued in a conventional teacher-centric mode of teaching. Again, the hypothesis that tested permanency of learning through EEG in the individual and collective modes stands justified.

The teachers during the semi-structured interview stated that the collective mode of EEG was superior to the individual mode in many different ways. The teachers gave examples where the students had abandoned certain sums in mathematics, having considered them too difficult for them, but their interaction with the group enabled them to understand the logic and they could now solve them, thus leading to the conclusion that the collective mode was a better mode of learning. The teachers also observed that the students in the collective mode of teaching solved more sums, on average, whereas in the individual mode, only a certain number of students who had developed proficiency could solve many sums. The permanency of learning will also be in favour of collective EEG as the discussions between the students make it last longer in their minds.

In terms of the influence of gender difference on individual and collective EEG, it can be concluded that the teachers are of the opinion that the involvement of the students either with the games or the group will be the same, irrespective of gender, in terms of achieving both the learning outcome and permanency of learning. This observation of the teachers justifies the hypotheses testing in terms of gender difference.

Regarding the teacher perspectives about EEG usage in the individual and collective modes, the teachers were quite optimistic about the fact that it would add value to the learning process.

The greatest challenge they anticipate is the shifting of the paradigm of teaching by the teachers from the conventional mode to EEG-based teaching. They conveyed the fact that, while it is unwise to make the students completely dependent on electronic gadgets for learning, it was advisable to reduce the conventional chalk and talk kind of lectures and supplement them with EEG-based learning.

To summarize, the qualitative research not only provided the justification for the results obtained through the quantitative analysis mainly in the form of hypotheses testing, but also answered why the association between the variables of research interest has taken place. The analysis of the qualitative data also provides a strong foundation to make suggestions about improving upon the quality of EEG-based learning in the individual and collective modes.

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# CHAPTER 11

# Discussions and Recommendations

## 11.1. Introduction

The aim of the research has been to assess the impact of Educational Electronic Games (EEG) in mathematics learning in primary school when learning takes place in the individual and collective modes and make suggestions to enhance learning effectiveness. This chapter is dedicated to the discussion of various findings of this research in pursuit of the aforementioned aim of the research. The discussions are based on the findings of this researcher and the corroboration with contemporary research in terms of the agreements and disagreements and the emerging suggestions and recommendations to the primary education authorities in Kuwait about making EEG-based individual and collective learning more effective.

## 11.2. Discussions and Recommendations

1. The testing of hypotheses 1 and 2 indicate that both individual and collective EEG have a significant influence on the learning achievement in mathematics both in the short term as well as a permanency of learning basis. This revelation is in tune with the earlier researcher findings (Malone, 1981; Rieber, 1996; Squire, 2005; Barab et al., 2005; Young-Loveridge, 2005; Bragg, 2007; McGivern et al., 2007; Simpson et al, 2006; Qiaolei, 2014) and is in direct contrast to the outcome obtained by another group of researchers (Asplin et al., 2006; Ke, 2008; Fengfeng, 2008; and Kim and Chang, 2010). In the context of the Arab world, there has been little empirical work in this direction and this revelation is quite encouraging to the proponents of EEG-based learning in both the Individual and Collective modes.

   Both the qualitative observation during the experimentation and the revelation of the quantitative analysis converge on the point that EEG usage helps students to achieve the required level of learning attainment and also supports the permanency of learning. Thus, with confidence, it can be recommended that the Ministry of Higher Education authorities must encourage and support primary schools to adopt EEG and deploy its capabilities in all courses, wherever possible. Simply providing the infrastructure may be insufficient; there is a need to provide training for teachers on the effective usage of EEG as a supplement to classroom teaching, and an ambience must be created where the students become self-reliant through the usage of EEG. However, it is important to note that the first two hypotheses did not have a control group and hence the results cannot be considered as a strong claim to the point.

2. The testing of hypothesis 3 has revealed that collective EEG-based learning is producing significantly better results than individual EEG-based learning. This was observed during the field work undertaken in class. There was a healthy interaction between the students and all of the conversations were subject-oriented, focused towards the assimilation of information and pertaining to the problems being solved by the students collectively.

   The theory of collective learning indicates that collective learning promotes student communication (Ke, 2008). Peer communication has a better learning effect than the monologue- or sometimes dialogue-based teacher communication because collective learning promotes even multi-logue communication. It was observed during the entire duration of collective gaming that the students participated wholeheartedly, expressed their feelings openly and, most importantly, social interaction was very prominent. The mental process elaboration was also dominant and the students did not accept blindly what their peer group said when they approached them with a request for help. The whole interaction was enjoyable to the students as it was in a play mode rather than a serious discussion about the subject. Collective learning promotes cognitive elaboration in a naturalistic manner (Fe, 2008). The students were executing their skilful questioning ability to elicit the information they need to learn from their peer group during mathematics problem-solving. The general observation was that, when approached about a problem, the students would directly give the answer, but the inquirer would ask why he/she has to execute those steps to reach the answer and inquisitively learn the techniques or methods so that he/she can apply it to future situations. Thus, collective EEG promotes cognitive elaboration.

   So, it is recommended that schools must encourage more collective mode teaching. There are two issues here. The first is that the students must be turned into independent learners who can interact with the group and co-create knowledge and, second, the teacher must learn how to be a good facilitator of learning. While there is no single method for promoting the collective mode of learning through EEG, the teachers may explore several ways of promoting constructivism through indoor as well as outdoor activities in schools.

3. The testing of hypothesis 4 has revealed that collective EEG-based learning is producing significantly better results than individual EEG-based learning in connection to the permanency of learning. Learning is a cognitive process that involves a series of activities, including comprehension, understanding, registering, recalling etc., and what is learnt has to be remembered by the students for the rest of their lives. While some kinds of knowledge may be registered and can be recalled for a long duration of time, other kinds of knowledge may not be recalled. It depends upon several factors which influence remembering, such as the way the knowledge was acquired, the importance given by the student to the knowledge, the interest with which the topic is studied, and the perceived usefulness of the new knowledge acquired. In the present research, the learners are all $5^{th}$ grade students, aged 9 to 10 years, and they may be unable to digest the usefulness of their acquired knowledge fully. However, the method through which they learn, the interaction which takes place during learning, and the interest that the method of learning can create can play a significant role. As mentioned before, the very purpose of EEG is to add the entertainment and fun elements to learning which is very appealing to students within the age group under consideration.

   By applying the metacognitive theory of learning, Finley et al., (2010) found that learning and remembering are a metacognitive activity during which a learner will set a desired state of learning and, when new knowledge is encountered, it will be compared with the existing state of knowledge in the mind so that the learner will monitor the current state and the desired state continuously. During the monitoring, if the current state of knowledge acquired is lower than the desired state, the learner will interact with his/her acquaintances to fill the gap. The remembering of what is learnt new will depend to a considerable extent on the way in which the new knowledge is understood by the learner. Sometimes, the anecdotes and examples may play a very dominant role and the graphics and animation which provides the new knowledge may also serve the purpose of remembering the content for a longer duration. For instance, if the concept is explained through an eyecatching diagram or interesting example, it will never be forgotten by the learner. The collective learning in fact has this advantage of making the learning process memorable as the learners learn in a collaborative manner. During this process, a lot of interaction will take place between the learners and it is this conversation that makes learning permanent. All of these observations provide a base for the recommendation that the teachers must explore more collective modes of EEG usage both in the indoor and outdoor forms.

4. The testing of hypothesis 5 revealed that gender difference does not play a role in influencing individual or collective EEG-based learning. Many researchers observed the influence of gender difference in various electronics-based learning scenarios (Upitis, 1999), but this was during the earlier stages of the evolution of computer technology. With the advent of computer technology and higher level of exposure of the students (both male and female), the influence of gender difference on the amount of learning that takes place now appears to be insignificant. Studies have shown that male students are more attracted to the competitive aspects of EEG (Hartmann & Klimmt, 2006), and played more EEG compared with female students (Kinzie & Joseph, 2008), but in terms of the learning that takes place, there is no clear evidence of any significant difference between the two genders. Earlier researchers also found that there is little change in the cognitive domain of the students based on gender while learning takes place through the use of EEG (Ke & Grabowski, 2007; Papastergiou, 2009 and Annetta et al., 2009). However, there are also studies which have observed the gender difference in learning through EEG (Kim & Chang, 2010).

   As there is no gender influence on learning achievement using EEG in either the individual and collective modes, it is recommended that primary schools might adopt the same learning environment for both genders. There is no necessity to increase the interaction among students, or adopt a different strategy for a particular gender to make learning through EEG more effective. This observation is only applicable to the Kuwaiti context of education and generalization may not be appropriate in the global context.

5. The testing of hypothesis 6 revealed that gender has no influence on the permanency of learning that takes place through either individual or collective EEG in terms of the

permanency of learning. Permanency of learning has a role to play in the performance of the students in the subsequent years of study as well as their whole life. It is not how quick a learner comprehends a concept that matters, but how permanent it is in their mind that matters. No learning at a higher level can takes place without prerequisite knowledge of some kind. According to Holton et al. (2001), a EEG in mathematics may have features such as: a solution-centered activity with the solver in charge of the process, that uses the solver's current knowledge, develops links between the solver's current schemata while play is occurring, reinforces the current knowledge through the links developed, assists future problem-solving mathematical activity, and behaviour occurs irrespective of age or gender. This demands some kind of permanency of learning which has to take place. However, forgetting is ubiquitous, irrespective of gender, and it has been observed that, even among adults, 25-35percent of basic science knowledge is forgotten after a year, more than 50percent by the second year, and 80-85percent after 25 years (Custers, 2010; Custers and Ten Cate, 2011; and Lindsey et al., 2013). The possibility of gender difference could have been expected in a country like Kuwait where this study was carried out because, since childhood, girls remain inside the house comparatively, assisting their mother with household work whereas boys are always out of the house and have a wider exposure to the external world. Further, the interaction between the genders is extremely limited compared to the western world. These aspects of lifestyle might have influenced the permanency of learning but, interestingly, this research has indicated that there is no gender difference with regard to the permanency of learning mathematics. The recommendation remains the same as in the previous section.

6. Teachers' perception about the usefulness of EEG in the individual and collective modes is very important because, unless they are convinced about the usefulness of EEG, they will not promote it. EEG cannot be popular and students will never take EEG-based learning seriously unless the teachers inform them that it is useful. One group of researchers has found that EEG has not received its due importance and the main reason was the perceptions of the teachers about its effectiveness (Can and Cagiltay, 2006). These perceptions in turn are based on the teacher characteristics, such as age, gender,

educational qualification, experience, etc. (Molenda & Bichelmeyer, 2005). The revelation of this study is important in the sense that the schools should not take the teacher characteristics lightly at the time of recruitment as well as during their development stages. The qualitative research in the form of semi-structured interviews endorses this view. Teachers' inclination towards innovativeness in teaching and its importance, their view about flexibility in teaching-learning, societal views, cultural influences, gender equity, play and gaming concepts, administrative views, curriculum considerations, etc., play an important role in the success of EEG-based teaching-learning which has to be considered by the school authorities.

It is recommended that the Ministry of Education must make teacher selection more standardized with clear specifications in terms of teacher characteristics, as the perceptions of the teachers about EEG usage significantly varies based on these parameters. Teachers with the right educational background who are computer savvy may be recruited in the primary schools, as the research study has revealed that the EEG achievement of the educational outcomes is a derivative of the educational background of the teacher, as indicated through the hypothesis testing. Teachers with a master's degree and a computer background may be preferred as they would be more techno savvy. The age of the teacher, their gender, designation, experience, and course taught were indicated to be independent of the teacher perception of the effectiveness of EEG usage, its usefulness perception and the achievement of the educational outcome, so recruiters need not be very particular about these characteristics of the teachers during the selection as long as the other criteria are met. However, the type of games used by the teachers for teaching through EEG usage did affect the teachers' perceptions of the effectiveness of EEG usage and usefulness and the achievement of the educational outcome and thus this demands the careful selection of EEG games in close consultation with the teachers.

7. The descriptive statistics on teacher perceptions reveal that, in terms of the individual-collective EEG readiness, the teachers perceived that the learner was expected to have adequate exposure to the knowledge of computer usage, that the parents promoted the

children in using electronic games in one form or the other, and that the selection of the electronic game played a major role in the effectiveness of EEG. In terms of the teachers' perception of the usage of EEG tools, the teachers laid emphasis on the EEG type and good time management skills. In terms of the teachers' perceptions of the impact of EEG methods on learners' achievement of the academic outcomes, the teachers emphasized the device learning skills on the part of the learners. Finally, the teachers agreed that teacher effectiveness is important in the EEG mode of learning.

8. The testing of hypothesis 5 revealed that teacher characteristics had a significant influence on their perceptions of individual/collective EEG. This revelation is important because earlier studies have shown that the teacher's role in the success of EEG education can never be undermined because it is they who decide its implementation (Oldfield, 1991, Alexander & James, 2005 and Sarama and Clements, 2009). So, first of all, they should be convinced about the usefulness of EEG in educational settings. This study revealed that their perceptions about EEG is based on teacher characteristics, which include age, gender, educational qualification, experience, designation, course taught, and type of EEG used. This prompts the authorities to pay importance to teacher characteristics during their selection and teaching so that they have a positive perception about EEG and support its implementation.
9. Hypotheses 6a, 6b, and 6c focused on the influence of the educational level of the teachers on individual/collective readiness, EEG usefulness, and EEG's achievement of the educational outcomes. All three hypotheses were supported and thus it is clear that the educational level of the teachers is linked to their perception of these three important aspects of EEG effectiveness as an educational tool. The educational institutes' authorities must focus on providing quality education to the teachers so that they can develop a positive perception about the effectiveness of EEG.
10. Hypotheses 7a, 7b, and 7c tested the influence of age of the teachers on individual-collective readiness, EEG usefulness, and EEG's achievement of the educational outcomes. Surprisingly, all three hypotheses were unsupported, indicating that there is no influence of age of the teacher on their perceptions about EEG effectiveness. This indicates that the

college authorities can have a good mix of teachers of all different ages, as this will not influence their perceptions of EEG's effectiveness. However, as per the revelation of earlier hypothesis testing, irrespective of their age, their educational qualifications should be competitive as these do influence EEG's perceived effectiveness.

11. Hypotheses 8a, 8b, and 8c tested the influence of gender of the teachers on individual/collective readiness, EEG usefulness, and EEG's achievement of the educational outcomes. Gender difference research has been a focus in a conservative society such as Kuwait and there are discussions in several educational forums on whether female students must be taught by female teachers and vice versa. According to the research results, none of these three hypotheses are supported and gender difference has no influence on the teachers' perceptions of the effectiveness of EEG so the college authorities can hire teachers purely based on their qualifications and experiences without regard to gender as far as EEG implementation in schools is concerned.
12. Hypotheses 9a, 9b, and 9c tested the influence of the designation of the teachers on individual/collective readiness, EEG usefulness, and EEG's achievement of the educational outcomes. It has often been suggested that the top level of management is supportive of technology, but does not receive proper support at the lower levels. However, the hypothesis testing revealed that, irrespective of designation, there is uniformity in the perceived effectiveness of EEG. In other words, the designations of the teachers have no influence on their perceptions of EEG effectiveness. Thus, EEG implementation and practice will elicit similar responses from teachers operating with different designations.
13. Hypotheses 10a, 10b, and 10c tested the influence of the experience of the teachers on individual/collective readiness, EEG usefulness, and EEG's achievement of the educational outcomes. It was surprising to note that even the experience of the teachers had no influence on their perception of EEG effectiveness. So, irrespective of the experience the teachers have gained in teaching, their perceptions on EEG effectiveness remained the same. The authorities may note that there is no need to over-emphasize the experience of the teachers when EEG issues need to be resolved or a strategy has to be developed for its successful implementation.

14. Hypotheses 11a, 11b, and 11c tested the influence of the course taught by the teachers on individual-collective readiness, EEG usefulness, and EEG's achievement of the educational outcomes. None of the hypotheses were supported and hence the course taught by the teacher has no significant influence on the perceptions of the teacher about EEG effectiveness. Again, teachers from across the disciplines perceive EEG effectiveness uniformly so the decisions regarding the strategic planning or implementation of EEG in schools need not be based on the teachers' specialization and all may be involved in the process.
15. The qualitative component of the questionnaire survey of the teachers produced qualitative inputs for this research. The outcomes are in alignment with the results of quantitative analysis to a great extent. The teacher perceptions as per the descriptive statistics indicated that the knowledge of computer usage was adequate on the part of the students as they had exposure to the electronic gadgets in one form or the other. This indicates that the students by their very nature and choice have exposure to electronic gaming. In qualitative terms, through the open-ended questions, the teachers claimed that it is the freedom the students get and the flexibility in learning mathematics at their own pace that made EEG a pleasant experience to them. The teachers wanted the EEG-based learning experience to be completely different from that of typical classroom-based learning so that the students would have a particular sense of ownership towards learning. This leads to the point that, as the students already had earlier exposure to electronic gaming in one form or another, they will feel comfortable with the approach and make the best use of it. When they are left to explore the topic on their own with minimum teacher intervention, they enjoy the ownership of learning and the entertainment and fun element of EEG can keep them engaged for more hours. In addition, the qualitative response to the survey by the teachers clearly indicated that EEG is very promising
16. The qualitative data collected through the teachers match very well the quantitative analysis undertaken through the student data and thus supplements the hypothesis testing using the student data. The teachers stated that more emphasis has to be placed on the collective mode of learning through EEG and highlighted very clearly its importance. They

enumerated how collective EEG would be very effective in learning due to the social dimension attached to learning which is not present in individual EEG-based learning. Thus, the revelation of the hypotheses through the student data and the analysis of the qualitative teacher inputs match, leading to the conclusion that collective EEG-based learning should be given more importance as it is effective in facilitating learning.

17. The qualitative data obtained through semi-structured interviews has given some insights into EEG-based learning. The quantitative analysis was indicative of the significant influence of the independent variables on the dependent variables of the study but it does not answer the 'how' or 'why' aspects of causation. But, in the semi-structured interviews, through the open-ended questions, the interviewees provided the answers to these aspects. First, both the respondents claim that the collective mode of EEG is better than the individual mode, as it adds the social dimension to learning. The respondent clearly stated that, when student 'learning' is under scrutiny, for any meaningful outcome, the overall learning should be considered which includes their ability to develop lifelong learning skills and so the mere evaluation of performance in tests or examinations is inadequate. The reason cited is that, when the student learns a topic, he/she not only learns the content but also learns how to learn through interactions with others, develops motivation to learn further, and makes learning a habit which he/she can extend for a life time. While individual learning can cover certain aspects of this, collective learning can cover almost all of them. The students learn how to learn individually first and then compare their knowledge base with that of others. They also check whether their methods and procedures for solving a problem is the most effective one or whether it needs to be refined. The students learn how to seek information and also how to disseminate information in a socially acceptable manner. They learn how to air their opinions about an issue and develop negotiation skills as they compare and contrast their ways of solving problems with that of others. One of the respondents observed a student saying,

*"I used to give up certain difficult problems as I could not find a way to solve it. But, in the collective mode, my friends explained to me in such a simple manner how to solve those problems so that now I know how to tackle even difficult problems."*

This clearly shows that, first of all, the students have a desire to learn a topic to the full, irrespective of its complexity, and when it is difficult, they give up on learning only when they do not have a means to learn. EEG supports them in two ways: the first it makes them learn on their own at an appropriate pace of learning and complexity level and takes them through it in stages; second, it provides them with an opportunity to interact with their fellow students and this gives a social dimension to learning. This two-fold approach to learning makes EEG-based learning more dynamic and interesting as well as entertaining to the students.

The other issue often discussed in the context of Arab world in general and Kuwait in particular is gender difference. There are a large number of researchers who have undertaken a detailed study on gender difference in connection with the assimilation of knowledge, skills and attitudes. The study proved inconclusive and the current research makes an attempt to add to the existing knowledge in this area. The quantitative analysis has indicated that there is no difference based on gender as far as learning is concerned as measured through the scores obtained in the pre- and post-conditions. The qualitative analysis as per the primary data through the questionnaire has substantiated to some extent this result by indicating that there has been a free mix of the students during collective EEG-based learning, but semi-structured interviews with the two teachers provided more supportive evidence of the fact that there has been no gender influence on the amount of learning that has taken place through the two methods of EEG under investigation. It also explains why there is no influence of gender on learning. The following is a direct excerpt from the semi-structured interviews, where a teacher cites the words of a female student:

*"I always had a sort of inhibition to communicate with male students and I used to feel very comfortable with students of my own gender. I never used to interact with the male students in the class. But, the collective mode of learning using EEG made us work as a team of both genders. For the first time, I found that it is easy to communicate with the male students and there is no difference in the way they communicate and they are as friendly and helpful as my female friends. It completely changed my attitude and behaviour towards*

*the class and now I have one class full of friends who help me and seek my help in learning and as a team I feel we can perform much better than as an individual. I keep looking for more such activities in the class where we can solve the problems in groups."*

It is thus clear that the students have uniform opportunities and that both males and females can make use of the facilities as well as the opportunity to learn in a group. Except for the psychological and cognitive disparity between the genders in terms of their ability to learn and comprehend, there cannot be a difference in either the amount of learning or the permanency of learning that has taken place. However, the pace of learning and grasping power is the individual ability of a student and there could be a difference, the study of which is beyond the scope of this research.

# CHAPTER 12

## Conclusions

This research had several purposes. The purpose was to find empirical evidence for the influence produced by the individual and collective modes of EEG on student achievement in mathematics learning and also the influence on the permanency of learning. Studying the differential influence of individual and collective EEG-based learning was another purpose of this research. Finding the influence of gender difference on individual and collective EEG-based learning achievement as well as permanency of learning was also the purpose. Finally, the research purpose was to elicit the perspectives of teachers about individual and collective learning as well as to determine the influence of teacher characteristics.

The quantitative analysis indicated that individual and collective EEG have a significant influence on achievement in mathematics learning as well as permanency of learning. The qualitative analysis revealed that individual and collective EEG-based learning can provide a shift from the teacher centric-teaching to learner-centric learning, which gives a sense of ownership to the learner and can improve the learning achievement. The fun and entertainment element added to the learning of mathematics through EEG in the individual and collective modes that enhances student engagement which also makes them develop an interest in learning thus leading to better performance as well as permanency in learning.

In terms of the influence of gender difference, it was concluded by the quantitative analysis that gender has no influence on the performance of the students when taught through individual or collective EEG-based learning or on the permanency of learning either. This revelation was supported through the qualitative analysis through the questionnaire survey as well as semi-structured interviews. The teachers observed that the students were thoroughly involved with the gaming mode of learning, irrespective of gender, and when it was through the collective mode, there were a free exchange of ideas and the students were found to be freely interacting with each other by helping each other so it could be concluded that gender had no role to play either in the achievement of the educational outcome or in the permanency of learning.

The capturing of the teacher perspectives about the present and future of EEG in the individual and collective modes has been a very fruitful outcome of this research. The teachers are quite positive about the contribution that EEG can make to the imparting of mathematics education in a very creative manner. The teachers expected the students to have adequate knowledge about computer usage, expected parental support on computer usage, and also perceived that the selection of the EG was important for its success. The students were expected to have time management skills and also opined that teacher effectiveness is the key to the success of EEG. It was also observed through the quantitative analysis that the background characteristics of the teachers had a significant influence on the usage of EEG. This is an important revelation in the sense that, unless the teachers have a background which is conducive to the promotion of EEG usage, there is no guarantee that the usage of EEG may be promoted in primary school.

Specific suggestions to the primary education authorities emerged though the studies. As EEG-based learning produces better learning achievement as well as permanency of learning, the investment on EEG in schools is worth the cost and the government may invest in the development of the infrastructure required for EEG. The primary education authorities may also encourage the teachers to adopt more of collective mode of teaching using EEG as it has a better influence on both learner achievement and permanency of learning. There is no need to provide special attention to either male or female students during EEG-based learning in the individual or collective modes of learning, as there is no difference between the performance of the students observed in the individual or collective modes based on the gender of the students. Primary schools should recruit teachers with an inclination towards innovativeness in teaching, flexibility in teaching-learning, societal views, cultural sensitivity, gender equity, play and gaming concepts, administrative views, curriculum up-gradation skills, etc.

Kuwaiti government is keen on developing the local manpower to occupy the key positions in both the production and service sectors of the country, particularly in the government and public sector. Techno savvy manpower will become a future requirement in Kuwait to survive in the global market. The onus is thus on the primary schools to design and develop a curriculum which meets the future demands of society and also to adopt technology in many different forms to make the teaching/learning process effective in terms of knowledge assimilation as well as the imparting of transferable skills, such as soft skills and computer usage knowledge. So, it is in this context that the presented research is timely and the suggestions made to the primary education authorities are worthy of consideration, as they aim to improve the effectiveness of the teaching-learning process. Finally, as stated before, even though the research findings are purely based in the context of Kuwait, some of the suggestions are of universal context and primary school administrators outside Kuwait may also implement these recommendations to promote learning attainment of the students.

This study has enhanced the general understanding about the individual and collective electronic games on mathematical learning achievement in the context of Kuwait. When there was no adequate literature support in the form of empirical study, particularly in Kuwait, this research has provided conclusive evidence to the impact that these two modes of electronic games can have on the mathematical learning achievement. Thus, the teachers and the policy makers of primary education in Kuwait can make use of the findings of this research study for the betterment of the processes in learning mathematics. The research has also opened up ample scope for the future researchers to further extend the study across the Arab world and undertake a comparative analysis so that there would be a better understanding of the learning scenario in this part of the world. This extension of the study can enable the sharing of the best practices with reference to the individual and collective electronic games. In this modern era where electronic mode of teaching-learning is becoming popular day by day, seeking of the empirical evidences for the impact that these tools can produce can be a continuous process as the efficiency of the tools is enhanced continuously through the refinements in the software and hardware.

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## Appendix 1: The Questionnaire

**Purpose:**

Evaluating the Impact of Individual/Collective Mathematical Educational Electronic Games (EEG) on Mathematical Learning Achievement in Primary School.

| Sample No: |
| --- |

**Author's Declaration:**

The data collected in this research will be solely used for the academic research purpose and the identity of the respondent will not be revealed anywhere.

Country: Kuwait

Institution:

Name Rabab Al-Safar

Participant Information: (Optional)

Date: Telephone:

Name:

**Background**

This research questionnaire is designed to explore teacher perspectives about the use of EEG as a means of teaching mathematics in Primary School in the individual and collective modes.

1. **Teacher background Information** (Please tick (√) in the appropriate row)

| No. | Question | Answer |
|---|---|---|
| 1 | *Education level:* | |
| | 1. Diploma. | |
| | 2. Graduate. | |
| | 3. Post-graduate. | |
| | 4. Ph.D. | |
| 2 | *Age:* | |
| | 1. Less than 30 years old. | |
| | 2. 30 to 45 years. | |
| | 3. Greater than 45 years old. | |
| 3 | *Gender:* | |
| | 1. Female. | |
| | 2. Male. | |
| 4 | *Designation* | |
| | 1. Class teacher | |
| | 2. School Principal | |
| | 3. Programme Director | |
| 5 | *Experience in teaching* | |

| | | |
|---|---|---|
| | 1. Less than 5 years | |
| | 2. 5 to 10 years | |
| | 3. More than 10 years | |
| 6 | *Course taught/teaching* | |
| | 1. Mathematics | |
| | 2. General Sciences | |
| | 3. Others (please Specify…………………..) | |
| 7 | *Electronic game used* | |
| | 1. Battery-operated Games | |
| | 2. Software Game | |
| | 3. Others (please Specify…………………..) | |

## 4. Individual-Collective EEG Readiness

| No. | Questions on: Identifying the (individual-collective) electronic games **Readiness** | Behaviour Frequency | | | | |
|---|---|---|---|---|---|---|
| | | Strongly Agree | Moderately Agree | Neutral | Moderately Disagree | Strongly Disagree |
| **Knowledge of Computer Usage** | **1.** The Learner is expected to be a computer user at home | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 2. The Learner is expected playing electronic games at home | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 3.The learner is expected to be mathematic iPAD user | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 4. The learner is expected to have learned iPAD at school | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 5. Parents are expected to have helped the Learner to play iPAD | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 6. The Learner is expected to be using iPAD games in Learning | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 7. The Learners is expected to be responding to the activities in mathematics | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 8. The Learner is expected t be performing while playing mathematics | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 9. The Learner is expected to be listening and observing and selecting proper choice | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Parents Skills** | 10. The parents frequently support the Learners in playing the electronic games in mathematics | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 11. The parent rarely support the Learners in playing the electronic games in mathematics | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 1. Parents and not the school select the Math Games | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 13. Parents are so keen in selecting the games | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 14. Parents are familiar with the electronic games as per the Math chapters in the math book | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 15. Parents are guiding the Learner in answering the questions | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 16. Parents are familiar with the speed limit of answering the questions | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 17. The mother is mainly involved in teaching the Learner | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Selection of Electronic Game** | 18 The selected Game was a board shape rather than cardboard sheets | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 19 The selected Game is used as a Group Learning Tool | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 20 The selected Game is used as an individual Learning Tool | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 21 Magic Math is a proper electronic game for 10-11 years old learners | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 22 Math kid is a proper electronic game for 10-11 years old learners | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 23 Kids Math is a proper electronic game for 10-11 years old learners | ☐ | ☐ | ☐ | ☐ | ☐ |

## 5. Usefulness of EEG Tools

| No. | Questions on: Identifying the EEG Methods useful in primary school classes for teaching purposes | Behaviour Frequency | | | | |
|---|---|---|---|---|---|---|
| | | Strongly Agree | Moderately Agree | Neutral | Moderately Disagree | Strongly Disagree |
| **EEG Types** | 24 The selected game has to offer the Learners an insight on how to approach mathematic skills | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 25 The game has to have options on learning how to avoid doing a mistake | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 26 The game should use different ways to answer the questions to help learner to figure out there are many ways to answer | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 27 The selected game should have means to grab proper attention to solve the questions | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Time Management Skills** | 28 The Electronics Information subtest of the selected game consists of multiple choice questions, which must be answered in 9 minutes. | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 29 The Electronics Information subtest of the selected game consists of missing answer choice questions, which must be answered in 4 minutes. | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 30 The Electronics Information subtest of the selected game consists of rate or ranking answer choice questions, which must be answered in 4 minutes. | ☐ | ☐ | ☐ | ☐ | ☐ |

## 6. Impact of EEG Methods on Learner Achievement

| No. | Questions on: Identifying the impact of individual/collective EEG on mathematics learning achievement | Behaviour Frequency | | | | |
|---|---|---|---|---|---|---|
| | | Strongly Agree | Moderately Agree | Neutral | Moderately Disagree | Strongly Disagree |
| **Device Learning Skill and Concept** | 31 Device practices include individual exploration | 1 | 2 | 3 | 4 | 5 |
| | 32 Device practice include , peer interaction, and small group work | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 33 Device practices emphasizes the use of multiple approaches to problem solving, | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 34 Device practices emphasizes on the active student ability | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 35 Device practices emphasize on the importance of linking mathematics to students' daily life | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 36 Device practices emphasizes the use of a multiple approach to problem solving | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Teacher Effectiveness** | 37 You are presenting a lecture as per a specific textbook | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 38 You are helping students to think critical | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 39 You are concerned with the electronic game subject area | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 40 You are applying student-Device knowledge in teaching | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 41 You are concerned with reform instructional practices in mathematics | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 42 You are concerned with the importance of examining the effects and relationship among types of instructional practices that student receives | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 43 You are helping learner in their scientific achievements and attitudes towards mathematics. | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 44 You are helping learner's in their scientific achievements and attitudes towards EEG | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 45 Teachers act of asking questions helps keeping students actively involved in lessons | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 46 Teachers allow students while answering questions, to have the opportunity to openly express their ideas and thoughts | ☐ | ☐ | ☐ | ☐ | ☐ |
| | 47 The Teacher is helping learners in their skills towards mathematics. | ☐ | ☐ | ☐ | ☐ | ☐ |

**Qualitative Inputs**

1. What are your specific suggestions to improve the individual learning of the students?

2. What are your specific suggestions to improve the collective learning of the students?

3. Do you find EEG useful in teaching/learning? If so why? If not, what are the reasons?

4. How do you think EEG has contributed specifically to the learning of Mathematics?

**With Compliments from**

**Author**

## Appendix 2: Semi-Structured Interview Protocol

Interviewer: **Rabab Al-Safar**

Interviewee:

1. Background Questions

   i. Tell me a little about your background.

   ii. How long have you been teaching?

   iii. What is your educational background?

   iv. Which grades have you taught and which courses?

   v. What special training have you undergone in educational methods?

2. When you heard about EEG, what was your first impression?

3. Can you share your experiences with learning through EEG?

4. What kinds of courses do you think can be studied through EEG effectively?

5. Can you give me an example where a student can learn more than traditional teaching through EEG?

6. Describe a typical classroom experience in dealing with EEG in the individual and collective mode.

7. What challenges did you face regarding using EEG in the individual and collective modes?

8. Can you compare and contrast the use of EEG in the individual and collective modes?

9. Can you comment on gender difference issues related to learning through EEG in the two modes?

10. Can you comment on the permanency of learning through EEG in the two modes?

11. Can you comment on the future of EEG?

12. Is there anything else you wish to share on this topic?

## Appendix 3: Data (Students)

Treatment A (n=37)

| Pre | Post | Diff | Post2 | Permanency | | Gender | Diff | Gender | Permanency |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 14 | 3 | 15 | 4 | 4 | 1 | 3 | 1 | 4 |
| 14 | 16 | 2 | 15 | 1 | 1 | 1 | 2 | 1 | 1 |
| 15 | 17 | 2 | 15 | 0 | 0 | 1 | 2 | 1 | 0 |
| 12 | 15 | 3 | 16 | 4 | 4 | 2 | 3 | 2 | 4 |
| 14 | 16 | 2 | 17 | 3 | 3 | 2 | 2 | 2 | 3 |
| 12 | 15 | 3 | 15 | 3 | 3 | 1 | 3 | 1 | 3 |
| 14 | 17 | 3 | 17 | 3 | 3 | 2 | 3 | 2 | 3 |
| 15 | 17 | 2 | 16 | 1 | 1 | 1 | 2 | 1 | 1 |
| 16 | 18 | 2 | 16 | 0 | 0 | 1 | 2 | 1 | 0 |
| 15 | 16 | 1 | 15 | 0 | 0 | 1 | 1 | 1 | 0 |
| 12 | 13 | 1 | 14 | 2 | 2 | 1 | 1 | 1 | 2 |
| 13 | 16 | 3 | 15 | 2 | 2 | 2 | 3 | 2 | 2 |
| 14 | 16 | 2 | 17 | 3 | 3 | 2 | 2 | 2 | 3 |
| 15 | 17 | 2 | 18 | 3 | 3 | 2 | 2 | 2 | 3 |
| 14 | 15 | 1 | 16 | 2 | 2 | 2 | 1 | 2 | 2 |
| 15 | 17 | 2 | 18 | 3 | 3 | 1 | 2 | 1 | 3 |
| 16 | 17 | 1 | 18 | 2 | 2 | 1 | 1 | 1 | 2 |
| 14 | 16 | 2 | 15 | 1 | 1 | 1 | 2 | 1 | 1 |
| 15 | 16 | 1 | 17 | 2 | 2 | 1 | 1 | 1 | 2 |
| 13 | 16 | 3 | 17 | 4 | 4 | 1 | 3 | 1 | 4 |
| 13 | 15 | 2 | 16 | 3 | 3 | 2 | 2 | 2 | 3 |
| 14 | 16 | 2 | 15 | 1 | 1 | 2 | 2 | 2 | 1 |
| 14 | 15 | 1 | 14 | 0 | 0 | 1 | 1 | 1 | 0 |
| 14 | 16 | 2 | 15 | 1 | 1 | 2 | 2 | 2 | 1 |
| 15 | 17 | 2 | 18 | 3 | 3 | 1 | 2 | 1 | 3 |
| 14 | 15 | 1 | 16 | 2 | 2 | 2 | 1 | 2 | 2 |
| 13 | 16 | 3 | 16 | 3 | 3 | 2 | 3 | 2 | 3 |
| 15 | 17 | 2 | 16 | 1 | 1 | 1 | 2 | 1 | 1 |
| 16 | 18 | 2 | 18 | 2 | 2 | 1 | 2 | 1 | 2 |
| 13 | 15 | 2 | 16 | 3 | 3 | 1 | 2 | 1 | 3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 14 | 16 | 2 | 15 | 1 | 1 | 1 | 2 | 1 | 1 |
| 13 | 15 | 2 | 16 | 3 | 3 | 1 | 2 | 1 | 3 |
| 14 | 17 | 3 | 18 | 4 | 4 | 2 | 3 | 2 | 4 |
| 15 | 16 | 1 | 15 | 0 | 0 | 2 | 1 | 2 | 0 |
| 15 | 17 | 2 | 17 | 2 | 2 | 1 | 2 | 1 | 2 |
| 16 | 18 | 2 | 18 | 2 | 2 | 2 | 2 | 2 | 2 |
| 14 | 16 | 2 | 17 | 3 | 3 | 2 | 2 | 2 | 3 |

Treatment B (n=37)

| Pre | Post | Diff | Post2 | Permanency | Gender | Diff |
|---|---|---|---|---|---|---|
| 12 | 15 | 3 | 14 | 2 | 1 | 3 |
| 11 | 16 | 5 | 15 | 4 | 1 | 5 |
| 14 | 17 | 3 | 17 | 3 | 1 | 3 |
| 12 | 16 | 4 | 17 | 5 | 2 | 4 |
| 13 | 18 | 5 | 18 | 5 | 2 | 5 |
| 14 | 19 | 5 | 18 | 4 | 1 | 5 |
| 13 | 16 | 3 | 17 | 4 | 2 | 3 |
| 12 | 15 | 3 | 16 | 4 | 1 | 3 |
| 14 | 16 | 2 | 17 | 3 | 1 | 2 |
| 13 | 17 | 4 | 18 | 5 | 1 | 4 |
| 15 | 18 | 3 | 18 | 3 | 2 | 3 |
| 11 | 15 | 4 | 14 | 3 | 2 | 4 |
| 11 | 16 | 5 | 15 | 4 | 1 | 5 |
| 12 | 19 | 7 | 16 | 4 | 2 | 7 |
| 13 | 17 | 4 | 16 | 3 | 2 | 4 |
| 14 | 16 | 2 | 15 | 1 | 2 | 2 |
| 12 | 15 | 3 | 15 | 3 | 1 | 3 |
| 15 | 18 | 3 | 16 | 1 | 1 | 3 |
| 12 | 17 | 5 | 15 | 3 | 1 | 5 |
| 12 | 19 | 7 | 17 | 5 | 2 | 7 |
| 13 | 16 | 3 | 14 | 1 | 1 | 3 |
| 13 | 15 | 2 | 14 | 1 | 2 | 2 |
| 14 | 17 | 3 | 16 | 2 | 2 | 3 |
| 12 | 16 | 4 | 15 | 3 | 1 | 4 |
| 12 | 17 | 5 | 16 | 4 | 1 | 5 |
| 13 | 18 | 5 | 17 | 4 | 1 | 5 |
| 14 | 16 | 2 | 15 | 1 | 1 | 2 |
| 15 | 18 | 3 | 17 | 2 | 1 | 3 |
| 13 | 15 | 2 | 14 | 1 | 2 | 2 |
| 14 | 16 | 2 | 15 | 1 | 2 | 2 |
| 13 | 16 | 3 | 15 | 2 | 2 | 3 |
| 12 | 18 | 6 | 17 | 5 | 1 | 6 |
| 12 | 19 | 7 | 18 | 6 | 1 | 7 |
| 13 | 18 | 5 | 18 | 5 | 1 | 5 |
| 14 | 19 | 5 | 18 | 4 | 1 | 5 |
| 12 | 15 | 3 | 15 | 3 | 2 | 3 |
| 13 | 17 | 4 | 16 | 3 | 2 | 4 |

## Appendix 4: The Pre-test and Post-test

Pre and Post Tests
Date: Wednesday, April 16, 2014
Academic Supervisor:

الأسلوب والمفهوم السلوكي الإدراكي في التدريس باستخدام الألعاب الالكترونية :

المفهوم يقود المعلم نحو تطبيق العمليات السلوكية ويقود المتعلم نحو زيادة التحصيل العلمي على النحو التالي:

1. مؤشرات سرعة الاستجابة – Response Index
2. التخمين - Guessing
3. التكرار - Repeating
4. استخدام الألوان - The Use of Colours
5. التفكير التشعبي - Clustering
6. القصص والروايات التصويرية - Novels and stories
7. استخدام الشق الأيمن والأيسر للمخ - Right and Left Parts of the Brain
8.

TEST-1 Operations + -

| | |
|---|---|
| 5 + 4 = | 9........5........11 |
| 11 + 1 = | 15......10..........9 |
| 9 + ☐ = 13 | 6........9..........4 |
| 32 + ☐= 40 | 8...................10.................13 |
| 40 - 30 = | 90................70................10 |

| | | |
|---|---|---|
| 2 2 | 8 8 | 6 7 |
| 20 + | 3 0 - | 0 8 - |
| ----- | ----- | ----- |

TEST-2 Number Order and Relations

| | | | |
|---|---|---|---|
| 25 | | 27 | 28 |

26…………..25……….30

| | | | |
|---|---|---|---|
| 9 | 10 | | |

12/18…………..13/14……….15/16

Ascending Order الترتيب التصاعدي

| | | | |
|---|---|---|---|
| 30 | 40 | 50 | 60 |

| | | | |
|---|---|---|---|
| 60 | 50 | 40 | 30 |

| | | | |
|---|---|---|---|
| 25 | | 27 | 28 |

Descending Order الترتيب التنازلي

| | | | |
|---|---|---|---|
| 90 | 100 | 110 | 120 |

| | | | |
|---|---|---|---|
| 10 | 20 | 30 | 40 |

| | | | |
|---|---|---|---|
| 300 | 200 | 100 | 60 |

Re Order the Numbers in Ascending Manner الاک بر ال ی الا صغر من الاعداد اک تب

50, 60, 70, 80

330, 340, 350, 360

Re Order the Numbers in a Descending Manner الا صغر ال ی الاک بر من الاعداد اک تب

33, 44, 55, 99

900, 600, 700, 500

Re Order the Numbers in Ascending Manner لـ لا صغر الا صغر من الاعداد رتـ ب

770, 765, 707, 777

Re Order the Numbers in a Descending Manner رتب الاعداد من الاكبر الى الاصغر

225, 98, 187, 309

TEST-3 Relations and Comparing Numbers

10 □ 11 **> < =**

9 > □ 12……….8………..3

20 □ 30 > < =

90 = □ 90……….80………..30

125 □ 126 > < =

89 □ 98 > < =

360 □ 375 > < =

521 > ?

930 < ?

360 = ?

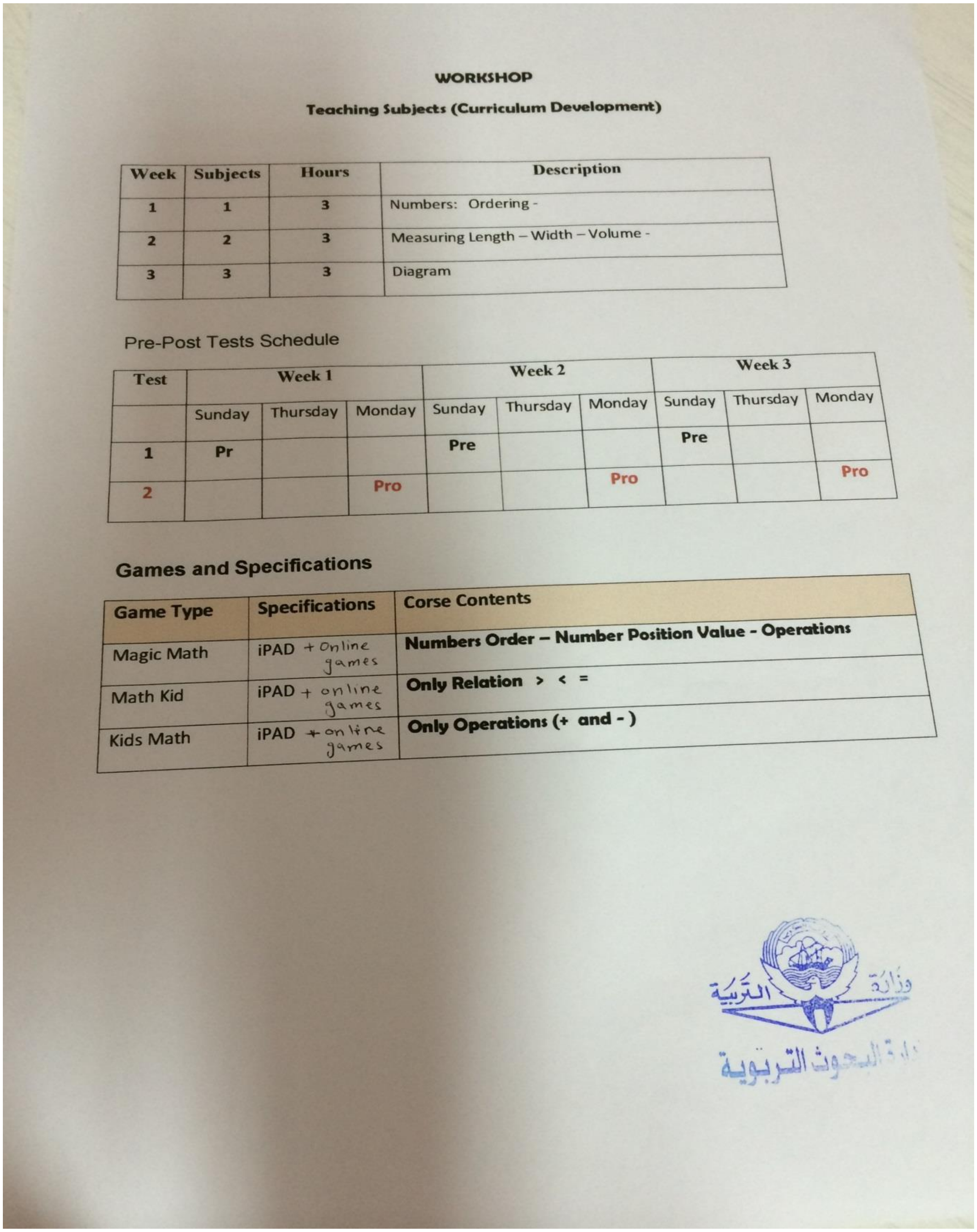
# Appendix 5 – Student Answers

Figure 9: Addition & subtraction

Figure 10: Number order & relations

Figure 11: Relational operators

Figure 12: Test for number proficiency



**WORKSHOP**

**Teaching Subjects (Curriculum Development)**

| Week | Subjects | Hours | Description |
|---|---|---|---|
| 1 | 1 | 3 | Numbers: Ordering - |
| 2 | 2 | 3 | Measuring Length – Width – Volume - |
| 3 | 3 | 3 | Diagram |

Pre-Post Tests Schedule

| Test | Week 1 | | | Week 2 | | | Week 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sunday | Thursday | Monday | Sunday | Thursday | Monday | Sunday | Thursday | Monday |
| 1 | Pr | | | Pre | | | Pre | | |
| 2 | | | Pro | | | Pro | | | Pro |

**Games and Specifications**

| Game Type | Specifications | Corse Contents |
|---|---|---|
| Magic Math | iPAD + Online games | **Numbers Order – Number Position Value - Operations** |
| Math Kid | iPAD + online games | **Only Relation > < =** |
| Kids Math | iPAD + online games | **Only Operations (+ and - )** |

وزارة التربية

البحوث التربوية

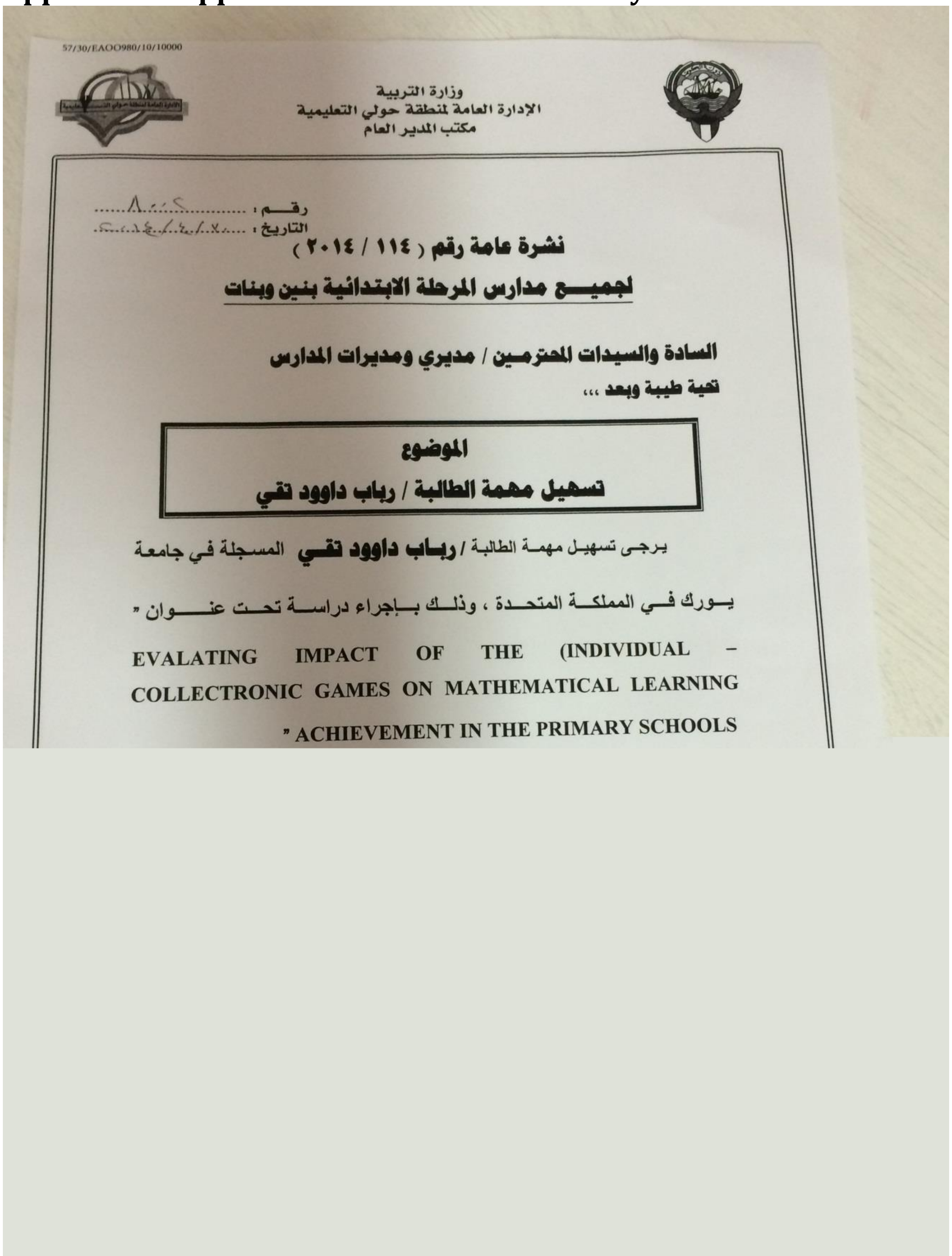
Figure 13: The Workshop Details

# Appendix 6: Descriptive Statistics

| | N | Minimum | Maximum | Mean | Std. Deviation | Skewness | | Kurtosis | |
|---|---|---|---|---|---|---|---|---|---|
| | Statistic | Statistic | Statistic | Statistic | Statistic | Statistic | Std. Error | Statistic | Std. Error |
| VAR00001 | 21 | 2.00 | 5.00 | 3.5714 | .74642 | .130 | .501 | -.094 | .972 |
| VAR00002 | 21 | 2.00 | 5.00 | 3.3333 | .79582 | .609 | .501 | .346 | .972 |
| VAR00003 | 21 | 1.00 | 5.00 | 2.9048 | .83095 | .189 | .501 | 1.874 | .972 |
| VAR00004 | 21 | 2.00 | 5.00 | 2.9524 | .66904 | 1.159 | .501 | 2.933 | .972 |
| VAR00005 | 21 | 2.00 | 5.00 | 3.5238 | .74960 | -.483 | .501 | .048 | .972 |
| VAR00006 | 21 | 2.00 | 5.00 | 3.3333 | .73030 | 1.072 | .501 | 1.135 | .972 |
| VAR00007 | 21 | 2.00 | 5.00 | 3.3333 | .85635 | .313 | .501 | -.215 | .972 |
| VAR00008 | 21 | 2.00 | 5.00 | 3.3810 | .80475 | -.208 | .501 | -.405 | .972 |
| VAR00009 | 21 | 2.00 | 4.00 | 3.2381 | .53896 | .200 | .501 | .027 | .972 |
| VAR00010 | 21 | 2.00 | 4.00 | 3.1905 | .60159 | -.071 | .501 | -.100 | .972 |
| VAR00011 | 21 | 2.00 | 4.00 | 3.2857 | .71714 | -.495 | .501 | -.802 | .972 |
| VAR00012 | 21 | 1.00 | 4.00 | 2.8571 | .79282 | -.394 | .501 | .154 | .972 |
| VAR00013 | 21 | 2.00 | 4.00 | 2.9524 | .74001 | .077 | .501 | -1.040 | .972 |
| VAR00014 | 21 | 2.00 | 5.00 | 2.9048 | .83095 | .767 | .501 | .498 | .972 |
| VAR00015 | 21 | 2.00 | 4.00 | 3.2857 | .64365 | -.330 | .501 | -.510 | .972 |
| VAR00016 | 21 | 1.00 | 4.00 | 3.1429 | .72703 | -1.092 | .501 | 2.785 | .972 |
| VAR00017 | 21 | 1.00 | 4.00 | 3.3333 | .73030 | -1.482 | .501 | 2.984 | .972 |
| VAR00018 | 21 | 1.00 | 5.00 | 3.5238 | 1.03049 | -.676 | .501 | .475 | .972 |
| VAR00019 | 21 | 3.00 | 4.00 | 3.4762 | .51177 | .103 | .501 | -2.211 | .972 |
| VAR00020 | 21 | 2.00 | 4.00 | 3.3333 | .57735 | -.128 | .501 | -.537 | .972 |
| VAR00021 | 21 | 1.00 | 4.00 | 3.0000 | .70711 | -.938 | .501 | 2.435 | .972 |
| VAR00022 | 21 | 2.00 | 4.00 | 3.3810 | .58959 | -.298 | .501 | -.608 | .972 |
| VAR00023 | 21 | 2.00 | 5.00 | 3.4286 | .67612 | .285 | .501 | .204 | .972 |
| VAR00024 | 21 | 2.00 | 4.00 | 3.2857 | .56061 | .038 | .501 | -.335 | .972 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VAR00025 | 21 | 2.00 | 4.00 | 3.3810 | .58959 | -.298 | .501 | -.608 | .972 |
| VAR00026 | 21 | 2.00 | 4.00 | 3.4762 | .60159 | -.662 | .501 | -.394 | .972 |
| VAR00027 | 21 | 3.00 | 4.00 | 3.2857 | .46291 | 1.023 | .501 | -1.064 | .972 |
| VAR00028 | 21 | 2.00 | 4.00 | 3.0952 | .53896 | .114 | .501 | .942 | .972 |
| VAR00029 | 21 | 2.00 | 4.00 | 3.2381 | .62488 | -.195 | .501 | -.365 | .972 |
| VAR00030 | 21 | 3.00 | 4.00 | 3.3810 | .49761 | .529 | .501 | -1.913 | .972 |
| VAR00031 | 21 | 1.00 | 4.00 | 3.1905 | .74960 | -1.124 | .501 | 2.492 | .972 |
| VAR00032 | 21 | 1.00 | 4.00 | 2.9524 | .66904 | -1.055 | .501 | 3.162 | .972 |
| VAR00033 | 21 | 2.00 | 4.00 | 3.4286 | .59761 | -.476 | .501 | -.560 | .972 |
| VAR00034 | 21 | 2.00 | 4.00 | 3.1905 | .60159 | -.071 | .501 | -.100 | .972 |
| VAR00035 | 21 | 1.00 | 4.00 | 3.1905 | .74960 | -1.124 | .501 | 2.492 | .972 |
| VAR00036 | 21 | 2.00 | 4.00 | 3.3810 | .58959 | -.298 | .501 | -.608 | .972 |
| VAR00037 | 21 | 2.00 | 5.00 | 3.5714 | .81064 | -.254 | .501 | -.129 | .972 |
| VAR00038 | 21 | 1.00 | 5.00 | 3.3810 | .97346 | -.528 | .501 | .590 | .972 |
| VAR00039 | 21 | 2.00 | 5.00 | 3.4762 | .87287 | -.169 | .501 | -.476 | .972 |
| VAR00040 | 21 | 1.00 | 4.00 | 3.1905 | .92839 | -.828 | .501 | -.294 | .972 |
| VAR00041 | 21 | 2.00 | 4.00 | 3.3810 | .74001 | -.774 | .501 | -.654 | .972 |
| VAR00042 | 21 | 2.00 | 4.00 | 3.3810 | .74001 | -.774 | .501 | -.654 | .972 |
| VAR00043 | 21 | 2.00 | 4.00 | 3.4762 | .60159 | -.662 | .501 | -.394 | .972 |
| VAR00044 | 21 | 2.00 | 4.00 | 3.4286 | .67612 | -.788 | .501 | -.350 | .972 |
| VAR00045 | 21 | 2.00 | 4.00 | 3.3333 | .73030 | -.631 | .501 | -.765 | .972 |
| VAR00046 | 21 | 2.00 | 4.00 | 3.2857 | .71714 | -.495 | .501 | -.802 | .972 |
| VAR00047 | 21 | 2.00 | 4.00 | 3.3333 | .73030 | -.631 | .501 | -.765 | .972 |
| Valid N (listwise) | 21 | 1.83 | 4.30 | 3.28 | .70 | -.25 | .50 | .21 | .97 |

# Appendix 7: Approval letter from the Ministry of Education



57/30/EAOO980/10/10000

وزارة التربية
الإدارة العامة لمنطقة حولي التعليمية
مكتب المدير العام

رقـــم : ٨٠٠٢
التاريخ : ٢٠١٤/٤/٢٠

**نشرة عامة رقم ( ١١٤ / ٢٠١٤ )**

**لجميـــع مدارس المرحلة الابتدائية بنين وبنات**

**السادة والسيدات المحترمـين / مديري ومديرات المدارس**

**تحية طيبة وبعد ،،،**

**الموضوع**

**تسهيل مهمة الطالبة / رباب داوود تقي**

يرجى تسهيـل مهمـة الطالبـة / **ربـاب داوود تقـي** المسجلة في جامعة

يـورك فــي المملكــة المتحـدة ، وذلــك بــإجراء دراســة تحــت عنـــوان "

EVALATING IMPACT OF THE (INDIVIDUAL – COLLECTRONIC GAMES ON MATHEMATICAL LEARNING " ACHIEVEMENT IN THE PRIMARY SCHOOLS

# Appendix 8: Semi-Structured Interviews

Interview - 1

| |
|---|
| Interview held on: 17$^{th}$ June, 2014 |
| Place: Salmania |
| Interviewer: Rabab Alsaffar |
| Interviewee: Teacher 5$^{th}$ Grade |
| Duration: 90 Minutes |

The objectives and purpose of the research is explained to the interviewee during the stage of seeking permission for the interview.

Interviewer:

1. *Sallam Alekum! (Greeting). May I know a bit about yourself and what attracted you to this profession?*

Interviewee:

Vaalekum Salam! (Greeting). I am a primary school teacher and my mother was also a teacher. I am passionately attached to teaching and this was my childhood ambition. After completing my undergraduate and post-graduate studies, I attended a number of training programmes in the UK and Kuwait and regularly updated my knowledge in my field. The training programmes included: Learn to learn, Educational technologies, Modern curriculum for primary schools, Challenges on the academic front etc. I am involved in the curriculum development of our school. Our school has a history of over 20 years and has grown rapidly since the past decade and is constantly striving to meet the technological challenges.

Interviewer:

2. *How long have you been in teaching?*

Interviewee:

I have been in teaching for the past 10 years.

Interviewer:

*3. May I know about your educational background?*

Interviewee:

I have a bachelor's degree in Social Sciences from a university in the UK and a post-graduate degree in Educational Psychology from the UK.

Interviewer:

*4. Which grades have you taught and which courses?*

Interviewee:

I teach 4$^{th}$ and 5$^{th}$ grade students in a co-educational school.

Interviewer:

5. What special training have you attended in educational methods?

Interviewee:

I have attended training in Training through technologies, Computer-based education, and Using Multi-media in educational programmes.

Interviewer:

6. When do you know about EEG? What was your first impression?

Interviewee:

The first exposure I had to EEG was in 2013 when I had attended a training programme on Training through technologies. I instantly realized that this could be future of education.

Interviewer:

7. Can you share your experiences with learning through EEG?

Interviewee:

We have implemented EEG-based learning in our school in some of the modules we teach. The game was loaded on the iPad (WolframAlpha). It was elementary mathematics computational software. It was very interesting to note how the fifth grade students reacted first when they were taught how to learn mathematics through this medium. In the first session, with minimum instructions, they were allowed to explore the game by themselves. Surprisingly, a large number of students had by themselves explored a number of games. The students were interacting with each other and the social activity was dominantly visible. The class had all of a sudden become vibrant and the students were excited and bubbling with energy. The reaction of one student was, *"Madam, why was this not given to us before? It is so easy to learn mathematics sums through this"*. Another student said, *"I never thought mathematics can be so easy"*. All these comments from the students were indicative so this is going to be the future of teaching through technology.

Interviewer:

8. What kinds of courses do you think can be studied through EEG effectively?

Interviewee:

I don't think there is a restriction on the type of course which can be taught using EEG, but in terms of effectiveness there could be some difference. Some subjects which are purely logical e.g., science and mathematics, can be made very interesting. The amount of learning that can take place could vary but I feel that EEG can be used in all the different courses.

Interviewer:

9. Can you give me an example where a student can learn more than traditional teaching through EEG?

Interviewee:

My own subject is an example. I teach mathematics and I feel when I teach in the classroom in a traditional manner the students need to be instructed to concentrate and every now and then I need to make sure they are with me in the process of learning, as it is mainly 'teacher centric'. Whereas when learning takes place through EEG, the students take ownership of their learning and participate actively in the exercise. They explore the topics with little or no supervision from the teacher. Learning is more fun and entertaining due to the graphics, animation and sound which are not very prominent in traditional teaching. The teachers have conveyed that it is the switch over from the teacher-centric teaching to learner-centric learning mode in both the individual and collective mode of EEG-based learning that makes learning more enjoyable. Further, the self-assessment enables the student to get feedback on his/her performance on the spot and immediately guides with the right answers as well as provides the approach to the right answers which will surely enhance the learning.

Interviewer:

10. Describe a typical classroom experience in dealing with EEG in individual and collective mode?

Interviewee:

Individual mode – We first explain the importance of the exercise to the students so that they may participate seriously in this exercise. We then give the standard instructions to the students on how to operate the EEG using the iPad. The game we used was computational mathematics using Wolfram Alpha. This software tool has mathematics from Elementary Mathematics to advanced mathematics. The software also covers Physics and Chemistry but in my class I have used it for simple mathematical operation teaching. It was used for teaching the mathematical operators in my class and there were exercises at varying levels of difficulty. It first gives a sum and the student can work out the solution. The software not only gives a solution but gives the steps which arrive at the solution and students can learn by themselves the procedure to arrive at the answer.

When the procedure was explained once using Powerpoint and the students were allowed to work independently, I found that the students thoroughly enjoyed the exercise. I could see the excitement on their faces which I don’t find when they learn through instructions in the traditional class. As it is the individual mode of learning, I ask them to follow my instructions and work out on the sums and at the end of the stipulated time of practice I give them a set of questions which they have to answer based on what they have learnt through the individual gaming exercises. I could find a drastic change in their performance level and my observation is that the students learn better when they are given the autonomy to learn. While taught in the class they behave as if something is being imposed on them and I can sense some resistance no matter how much of interest is generated and attempt is made to motivate them. This does not refer to about 5 to 10percent of the students who are naturally motivated towards mathematics and are keen to learn more but to a major chunk of the students who have other subjects of interest than mathematics. But when it comes to EEG-based individual learning, almost all of the students participate in the exercise actively.

Collective mode – This is group learning more in EEG-based learning and is one step ahead of individual learning. Individual learning takes care of the 'ownership' aspect of learning on the part of the student which was mentioned before, but collective learning adds the 'social dimension' to learning. It is the individual effort which makes the student learn the concepts of mathematics and apply them in solving the problems in the case of individual learning, but in collective learning the students learn in a group and exchange their ideas in collectively accomplishing the objectives of learning. In this mode, the students will not only learn mathematics but also learn a number of social skills which include communication skills, interpersonal skills, cultural sensitivity, knowledge sharing, and a spirit of inquiry.

My observation was that the students were more relaxed and participated as if they were in a playground rather than in a classroom. They were sharing their knowledge and were in a high state of energy to exchange their ideas. They were eager to share what they had newly invented and they were keen on accomplishing the tasks in a group. The whole class looked different and one student exclaimed after the class, *"Madam this class moves so quickly, why don't you conduct it for a longer duration"*. This shows how much interest the collective EEG had developed among the students and how eager they were to learn through this mode of learning. In conclusion, I wish to say the both individual and collective modes of EEG-based learning have a better impact than the traditional methods, even though they are not a replacement for it; however, the collective mode has a greater impact on the learning of the students than the individual mode of EEG-based learning.

Interviewer:

11. What are the challenges you faced in using EEG in individual and collective mode?

Interviewee:

The students were basically used to the conventional teaching methods and what was required on the part of the students was to shift to gaming more when they get into the EEG-based classes. This was not very easy to achieve as the students were in a gaming mode and not in the learning mode. So, class management was a bit difficult compared to the conventional classroom environment.

On the other hand, from the teachers' point of view, the greatest challenge is the shifting of the paradigm of teaching by the teachers from the conventional teacher-centric mode to the EEG-based learner-centric mode. They conveyed the fact that, while it is unwise to make the students completely dependent on the electronic gadgets for learning, it was advisable to reduce the conventional chalk and talk kind of lectures and supplement them with EEG-based learning.

One more challenge is to choose the most appropriate EEG software from a given set of available software. There is a huge number of EEG packages which can run on iPhones as well as other standalone systems such as Osmo iPad, LeapFrog LeapPad, VTech MobiGo, Fisher Price Fun-2-Learn, Y-Pad, and a whole lot of manufacturers with a variety of educational games in various subjects being released in the market. So, choosing the most appropriate one for a given grade is also a challenge.

Interviewer:

12. Can you compare and contrast use of EEG in individual and collective mode?

Interviewee:

In comparative terms, both EEGs are found to be more liked by the students in comparison to the traditional mode of learning in instruction-based classrooms. Students learn faster and develop a deeper level of understanding in EEG-based learning.

EEG in the collective mode is found to be the choice of the students as they can interact with the students as and when they find something difficult. Students solve more problems, on average, in a given time when put in the collective mode of learning than in the individual mode. In the individual mode of EEG-based learning, only those students who are familiar with EEG or have a higher level of ability in the usage of EEG solve more problems. I have a feeling that the topics learnt in the collective mode would last longer than that learnt through the individual mode because as they discuss the methods a lot, it may last longer in the minds of the students.

Interviewer:

13. Can you comment on gender difference issue related to learning through EEG in the two modes?

Interviewee:

My general observation is that male students are more computer- or techno-savvy than female students. But, of late, I have observed that female students also take a keen interest and in some cases they have outsmarted their male counterparts. According to me, the gender difference may be marginal and the gap is becoming narrower day by day and both would perform equally well.

Interviewer:

14. Can you comment on the permanency of learning through EEG in the two modes?

Interviewee:

According to me, permanency of a learnt concept is partially the capability of the individual and to some extent it may be based on the context in which it was learnt. EEG has an edge over traditional teaching in the sense that it can provide an animated picture and the graphics can be so powerful that they may aid the permanency to a considerable extent. In the context of traditional teaching, the teacher can also play that role and cite such everlasting examples or dramatize the concept so that it may be remembered permanently by the student. However, in terms of the individual and collective mode of teaching/learning through EEG, I feel that the collective mode would be better because of the social dimension added to learning, as I mentioned before.

Interviewer:

15. Can you comment on the future of EEG?

Interviewee:

I foresee a bright future for EEG-based learning. Online learning has now become very popular and the students find it very convenient to learn as they are employed. In the same way, iPad based games can be stored on the phones of the students and they can learn in both modes in their free time. So, this flexibility provides with the students an opportunity to learn as and when they want.

The future generation is going to be tech-savvy and EEG-based learning is designed for this generation. So, I very strongly feel that EEG-based learning is going to remain and become more powerful in the years to come.

Interviewer:

16. Is there anything else you wish to share on this topic?

Interviewee:

I have had an opportunity to see the educational system undergoing changes in the past two decades and technology has invaded all fields, including education. The traditional chalk and talk method of teaching has immensely benefitted from the introduction of multimedia and the sound, colour, and graphics and above all the animation has made learning more interesting to the students, but still the control was in the hands of the teachers and the teaching was still teacher-centric.

The scene has now completely changed and education has become learner-centric. I am very impressed by the concept of edutainment which is a combination of education with entertainment. EEG to a very great extent aligns itself with this concept so I strongly feel that EEG is here to stay. It may undergo many transformations such as individual to collective and the instructivist to the constructivist approach and so on but it is sure to stay around for a long time in the field of education.

Interview - 2

Interview held on: 19th August, 2014

Place: Safath

Interviewer: Rabab Alsaffar

Interviewee: Principal

Duration: 90 Minutes

Interviewer:

1. Good Morning! May I know a bit about yourself and what attracted you to this profession?

Interviewee:

Good Morning! I am basically from a business background and we have a family Automobile Dealership. It was my father who encouraged me to become an academic and I am here sitting as a Principal in this school. I have thoroughly enjoyed moulding the young minds and have a keen interest in educational psychology.

Interviewer:

2. How long have you been in teaching?

Interviewee:

I have been teaching for the past 30 years. I started as an instructor in primary school and then became a full time teacher and now am the Principal in the same school.

Interviewer:

3. May I know about your educational background?

Interviewee:

I have a bachelor's degree in Physics from a university in the UK and a post-graduate degree in Physics and then in Educational Psychology from the UK and also a PhD in Digital Story Telling from a university in the UK.

Interviewer:

4. Which grades have you taught and which are the courses?

Interviewee:

Before becoming the Principal, I was teaching grade seven students. I have taught Science and Mathematics to the students.

Interviewer:

5. What are the special trainings you have undergone in educational methods?

Interviewee:

I have attended more than 30 training programmes on diversified topics - Educational Technologies, Curriculum development, Digital Storytelling, Teaching using Multimedia, Literacy of the 21$^{st}$ Century, etc.

Interviewer:

6. When did you know about EEG? What was your first impression?

Interviewee:

We had invited a delegation from the UK to train our teachers in modern methods of teaching on a one week lecture series in 2013. One of the topics was Educational Electronic games.

Interviewer:

7. Can you share your experiences with learning through EEG?

Interviewee:

I find this method not a very new one but it has established itself very well in the western world for the past few years. It has also made an entry to Kuwait and we have had several sessions for our students on the use of EEG. I had been to a class of my colleague as an observer and the teacher used EEG in teaching mathematics. The sums were addition, subtraction, multiplication and division using EEG. When I observed the students participating more actively in the EEG-based learning in comparison to the conventional teaching, I realized that this method has a fun element and entertainment value for the students which attract them to this model of teaching. The teacher first made the students learn individually and then in a group. In fact, the teacher wanted to check their performance during the individual and collective mode of learning through EEG. I found that the students were engaged during both methods of teaching.

Interviewer:

8. What kinds of courses do you think can be studied through EEG effectively?

Interviewee:

I feel the courses which have strong logic and deductive reasoning to be developed by the students are more suitable for EEG-based teaching. More specifically, subjects like Mathematics and Science can be taught more effectively.

Interviewer:

9. Can you give me an example where a student can learn more than traditional teaching through EEG?

Interviewee:

The learning of mathematical operations itself is the best example I can think of. I found that EEG-based learning gives a sense of ownership, satisfies the individual’s needs, suits the individual’s speed and intellectual ability, promotes group learning, takes them through the process more systematically and in a structured manner, eliminates human error in teaching, offers challenges and promotes a competitive spirit, makes learning fun and entertaining through the usage of media, and thus, makes learning a pleasurable activity to the student.

Interviewer:

10. Describe a typical classroom experience in dealing with EEG in individual and collective mode?

Interviewee:

**Individual mode** – As mentioned before, I got into administration long ago but studied in depth modern technology-based education. In the classes where I observed the individual mode of learning, I observed that the students were fully engaged and the game had the ability to arouse the inquiring spirit in the students. The game was feeding the inquisitiveness of the students and the game not only provided them with the right answer when they could not reach it but showed the steps to reach it. It was clear that the students could learn the concepts by themselves with no teacher intervention in most cases. I could also observe that the students were learning with lots of interest and as the whole class was working towards solving the problems in a competitive mode every student was making the maximum effort to learn through the game. In total, I could observe that it was an engaged learning experience for the students.

**Collective mode** – In this mode, I found that, even though the learning was through the same sequence, the students were operating in a collective mode. They were free to share their ideas and there was enough scope for a person to receive as well as give ideas on how to solve a problem. The game encourages socialization to a great deal. What I feel about learning is it is not just the learning of the concepts but it is all about learning how to be a contributing member of society. Now, to be a contributing member of society, a person cannot operate in isolation but has to be a responsible citizen of the country, knowing very clearly all the roles and responsibilities. A collective EEG game is a very good example for training in group learning or collective learning. It is not enough if one learns but one should also help others learn. In the organizations in which one has to work, it is team work which would enable the organization to beat the competition and bring about innovative solutions to the problems. For innovation to take place, it has to pass through several iterations and the product or service has to be viewed from several different angles and it needs a collective wisdom. So, the students need to be trained to think in this direction and the collective mode of EEG is a very good way to start with this line of thinking. The students learn how to share their knowledge, they learn how to contribute to the group learning, they try to explore various alternatives, choose the best alternative, evaluate the ideas of others, analyze the problem by taking in suggestions from different people, convince others, make decisions, communicate effectively, participate as a team member and many more.

It is my general observation that students have a natural ability to recall pictures, diagrams and graphics with sound with much higher accuracy and for longer after learning in comparison to what they see or hear from the instructions in a conventional teacher-centric mode of teaching. So, what the students learn through the EEG mode will remain for a longer duration in their mind in comparison to that learnt through conventional, classroom-based learning.

The very participation as a team makes learning interesting to the students. They develop a sense of togetherness with the entire class. I have observed that they mix freely and adjust to individual differences. So, the collective mode of EEG has more to give than what we generally expect and it ultimately contributes to the collective wisdom of the group. I feel this method to be superior to the individual EEG in many different ways.

Interviewer:

11. What are the challenges you faced in using EEG in individual and collective mode?

Interviewee:

Training the teachers to accept this change in the mode of teaching will be an anticipated challenge. Because the teachers lose their importance to some extent even though they will still anchor the whole class. So, the teachers who are used to controlling the class through their traditional method of teaching may have to receive additional training to focus on ‘learning’ than teaching. So, training the teachers will be a challenge to be faced.

The development of the EEG for the individual and collective modes of learning will also be a challenge. The whole methodology needs to be developed by the teachers by considering the theories of educational psychology and cognitive psychology. The stages in which the students need to pass to arrive at a concept for problem-solving should be carefully designed and this is a challenge to be faced.

Conducting the different modes of EEG-based classes in the individual and collective modes itself is another challenge. There are a number of ways in which these two modes of EEG may be implemented and arriving at the most appropriate operational procedure will also be a challenge.

Interviewer:

12. Can you compare and contrast use of EEG in individual and collective mode?

Interviewee:

Both methods have the ultimate end result as the learning of the concept and developing the knowledge of the students. But the way in which it is achieved is different in the two methods. While the individual EEG is focusing on the individual effort of the learner, collective learning draws on the group learning ability of the learners.

When I asked the students about their opinion, one student said,

*"I used to give up certain difficult problems as I could not find a way to solve them. But, in the collective mode, my friends explained to me in such a simple manner how to solve those problems that now I know how to tackle even difficult problems."*

The above statement from the student makes the point clear how beneficial EEG-based learning is, particularly in the collective mode.

Interviewer:

13. Can you comment on gender difference issue related to learning through EEG in the two modes?

Interviewee:

There are several studies which I have come across in the context of the Arab world where student performance has been studied based on gender difference. In many cases, the researchers have observed a difference in the performance of the students based on gender. My observation is that, based on the psychological aspects, there could be a difference in the cognitive abilities of the male and female students and even the effort they put into their studies could vary. So, in generic terms, there could be a possibility of differential performance in studies between the male and female students. But, the question is whether the difference is statistically significant or not. I feel an in-depth research may have to be conducted to verify this point. Again, learning cannot be restricted only to the performance in the tests or exams and the grades they have obtained. Learning has to be measured on an overall basis and attitude, emotion, motivation, and the social dimension need to be evaluated to check if it is complete. There is no use if a student has scored very high grades and has not been a lifelong learner. So, speaking in these terms, I feel there may not be a gender difference in the learning that takes place through EEG. When I observed the class under the two modes of learning through EEG, I could see that the students were equally engaged in learning, irrespective of their gender. So, involvement-wise, both are equal and, in collective learning in particular, the interaction was also observed to be equal. Task accomplishment was also observed to be equal among the groups. So, it is my observation that there may not be any gender difference in the performance of the students in the individual and collective modes of learning through EEG.

When I asked the students to express their feelings about EEG-based learning, a female student commented,

*"I always had a sort of inhibition to communicate to male students and I used to feel very comfortable with the students of my own gender. I never used to interact with the male students in the class. But, the collective mode of learning using EEG made us work as a team with both genders. For the first time, I found that it is easy to communicate with the male students and there is no difference in the way they communicate and they are as friendly and helpful as my female friends. It completely changed by attitude and behaviour towards the class and now I have one class full of friends who help me and seek my help in learning and as a team I feel we can perform much better than as an individual. I keep looking forward to more such activities in the class where we can solve the problems in groups."*

Kuwait as a country, or in the Arab world in general, has its traditional roots and the interaction between the genders is less free than in the western world. The government has equal opportunity policies and in fact females are given tremendous opportunities to upgrade their skills and knowledge and occupy key positions in the government offices. But, researchers have a mixed reaction to gender difference in terms of their performance in education as well as in their professional career. Some studies have found a differential performance between male and female students, which others have not but, in the context of EEG-based learning, my observation supported by the above stated views of a student and many more which are not cited here and I feel there may not be any kind of influence of gender on their performance.

Interviewer:

14. Can you comment on the permanency of learning through EEG in the two modes?

Interviewee:

Learning things quickly and retaining what has been learnt are two different aspects. I have observed that the students may comprehend very quickly and forget at the same rate. On the contrary, students may comprehend slowly but retain the knowledge gained for a longer duration and apply it in future situations. While the teacher may be happy with the former set of students, the better performers would be the latter. So, permanency of learning is difficult to test as it has to be tested after a few months or years.

In the context of EEG, based on my personal observation of the process of learning, I can say that the retentiveness could be higher in EEG-based learning through the collective mode in comparison with the individual mode. This is because, in the individual mode, the student may follow the demonstration given in the game and follow the procedure of solving a problem and may master the process without much reasoning. But, in a group task, there is scope for discussion with the peer group and there is an opportunity to check what works and what doesn't and also why it works and how it works as the peer group is there to answer the questions. So, when learning takes place through a process of mutual agreement and disagreement, the chances of retaining that knowledge gained for a longer duration is higher. This is because the process is not going to be accepted by a group of students involved in the collective mode unless all are convinced. Also, the discussions which take place will make the students remember the process of conceptualization very well. Therefore, I can confidently say that learning through the collective mode would lead to better retention.

Interviewer:

15. Can you comment on the future of EEG?

Interviewee:

In today's information-driven world, technology is the driver. Technology has invaded all the fields and education is no exception. Technology has played a major role in revolutionizing education since the past decade and instructions in the classrooms are today mainly technology-driven. Several technology-driven areas of education are E-learning (Electronic Learning), M-learning (Mobile learning), W-learning (web-based education), MT-learning (Multi-media learning), U-learning (Ubiquitous learning – learning in any place at any time). So, the field of education today is completely technology-driven. The benefits of technology-driven education have been realized by academics and the field is growing. EEG is one such tool which can be practiced both in the individual and collective modes. It has produced good results in the western world and my personal opinion is that it will catch up in the Arab world too. EEG gives the students an opportunity to learn individually as well as collectively. Both of these types of learning are important for the overall growth of the student. What he/she cannot achieve individually, the student will be able to achieve in a group. In one way, it is an opportunity provided to the students to realize their own potential and then compare it with the collective knowledge so that they can learn from others and add to their individual knowledge. The students can compare their individual learning ability with that of the others and exchange their views with others. They can learn social skills which are vital for their future growth. So, in that sense, I strongly feel that EEG in both modes will have a long term impact on the educational scenario in the Arab world.

Interviewer:

16. Is there anything else you wish to share on this topic?

Interviewee:

As a teacher and then the Principal of a school, I have seen the role that technology has played in the overall growth of students. It has provided support both on the administrative as well as academic front in the context of education. My observation is that EEG has contributed to student learning in both the individual and collective modes. While traditional teaching appears to be teacher-centric and to some extent imposed on the students by the teachers, EEG-based learning will be student-driven. While individual EEG makes the students use their own creativity and inquisitiveness in learning, collective EEG brings the social dimension into the picture and makes the students learn in groups by helping each other in a systematic manner by sharing their knowledge. I very strongly feel that both EEG-based methods are useful in learning and make the students feel that they learn independently and it helps them to be lifelong learners.

# Appendix 9: Students working in the Individual and Collective Modes

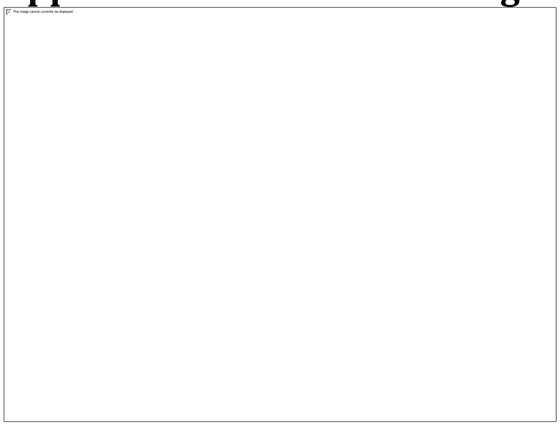


Figure 1: Treatment Group - A

Figure 2: Treatment Group - B

Figure 3: Collective Mode

Figure 4: Individual Mode

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