AN EXPERIMENTAL STUDY OF VCL AND CSCL TO ENHANCE STUDENTS' LEARNING ACHIEVEMENT AND ENGAGEMENT IN CHEMISTRY

BY

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Virtual Chemistry Labs (VCLs) are among the emerging technologies being used in education today. Of the various educational uses of this pedagogy, the focus of this research targeted two objectives; first, comparing the students learning achievement using VCL together with computer-supported collaborative learning (CSCL) to that of real labs (RL) and secondly investigating students' learning engagement using VCL together with CSCL. A quantitative study using pre-test and post-tests and classroom observations were used to measure the students' learning achievement and engagement respectively during chemistry lessons. The results of post-test indicated that students' learning achievement significantly increased after performing virtual chemistry lab experiments. The average post-test mean score was 34.25 as opposed to pre-test 26.65 before VCL and CSCL were applied to carry out the study. The significance level from post-tests of both groups was 0.000. This is a statistically significant figure implying that the experimental group had a better performance from the posts-tests than the control group. Similarly, observation results also indicated student engagement. In fact, 80% of the time was spent by students actively engaged in VCL activities and collaboratively working together with their peers. In addition to this research, possible directions for further research in the use of VCL were discussed.

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CONTENTS

CONTENTS (CONT.)

CONTENTS (CONT.)

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

Abbreviation	Meaning
VCL	Virtual Chemistry Lab
RL	Real Lab
CSCL	Computer Supported Collaborative Learning
PCR	Polymerase Chain Reaction
NRC	National Research Council
KVL	King's Visualization Lab
CALL	Computer Assisted Language Learning
CSCW	Computer-Supported Cooperative Work
CED	Collaborative Engineering Design
ZPD	Zones of Proximal Development
IOC	Item Objective Congruence
KR	Kurder-Richardson

CHAPTER 1

INTRODUCTION

This chapter describes the rationale of the study; objectives of the study; research questions; research hypothesis; scope of the study; limitation of the study; operational definitions; and expected outcome of the study.

1.1 BACKGROUND OF THE STUDY

It is compulsory for engineers, scientists and, doctors to study chemistry, but understanding its basic concepts is important for all of us. "Science is more than a school subject, or the periodic table, or the properties of waves. It is an approach to the world, a critical way to understand and explore and engage with the world, and then have the capacity to change that world" (Barack, 2015). Chemistry is one of the many science branches that teach us that everything around us is made up of matter – In fact, even our own bodies are made of matter! It is also involved in our daily lives, from growing plants and cooking to cleaning our bodies and homes to making chemical weapons like nuclear bombs.

Chemistry is taught in schools as a science subject and many students struggle to understand the fundamental chemistry concepts. Research has shown that chemistry had been regarded as a difficult subject for students by many researchers, teachers and science educators. It is quite uncertain if it's difficult really or there are factors that lead to this struggle.

Atagana and Engida (2014) research explored "difficulties in learning chemistry". Teachers and students both included as participants of the study, the research results revealed that both teachers and students were partly in agreement on the students' learning difficulties. Some of these learning difficulties were related to the course, and others were related to the students and teachers. Students were criticized the course content mostly, the teachers, the available resource, and the old fashioned teaching methods. However, only a few students blamed themselves that they do not do the work on their side. On the other hand, teachers were critical of course related factors, such as overcrowded classes, lack of resources and staff, and some other indirect factors such as student background and socio-economic conditions. Teachers partly blamed themselves as well. The findings suggested that there was a great deal of discrepancy between staff and student perceptions, although some points about the course related difficulties were shared by both sides.

Although it is not appropriate to generalize from one or two studies these results were also similar to a study that explored students' conceptions of equilibrium and fundamental thermodynamics concepts in college Physical chemistry of the University of North Colorado. In the same research, it seems from the students' main concerns and proposed solutions were of the increased demand in improvement of teaching and learning aspects. For example, propositions such as student motivation, use of educational technology in learning and teaching, understanding conceptual learning frameworks, establishing consistent exams, promoting student-centered learning and teaching as well as advocating for group activities were some of the concerns that needed immediate attentions.

The difficulties and some of the solutions presented by these two institutions give room for further research, therefore, this particular study focuses on two related disciplines that are further explained in the chapter as a possible solution to minimize the difficulties in learning chemistry; a) using technology to do laboratory experiments in chemistry and b) using technological tools like a computer to work in groups.

Teachers play a significant role in solving students' learning difficulties. According to Clow (1998), if teachers understand how students learn, then they can devise effective strategies for teaching. It's believed that engaging students in learning increase their retention and understanding of concepts. In fact, studies have shown that learner engagement is paramount to successful learning (Herrington, Reeves, & Oliver, 2010).

Hands-on laboratory experiences are critical to learner's engagement and the learning process across all areas of study in chemistry and other sciences like physics or biology. It is believed that teachers who prepare well-designed laboratory experiments find that their students are more engaged and find the subject more interesting. Chemistry experiments develop not only students' critical thinking but also their problem -solving skills and knowledge. Tobin (1990) suggests that learning by doing experiments in a laboratory provides students with opportunities to manipulate the equipment and materials in an environment suitable for them to solve problems. Furthermore, Tobin (1990) revealed that laboratory experiments allow students to learn with understanding, and engage them at the same time. Additionally, he defines these methods as fundamental in constructing the learner's knowledge.

Doing laboratory experiments provides students with opportunities if the expectations of the teacher enable them to engage with meaningful investigative experiences upon which they can construct scientific concepts within a community of learners in their classroom (Penner, Lehrer, & Schuble, 1998; Roth & Roychoudhury, 1993). Research has shown that doing laboratories is one way of helping students remember chemistry concepts. However, the use of technology to learn has proved to be even a more useful tool for students understanding of the knowledge taught. A combination of the two (laboratory with technology) would be referred to as killing two birds with one stone: a) students learn the use of computers which is a key skill in the 21st century; b) Students are able to learn laboratory practical skills through these simulations.

One of the many American scientists and a major figure in the American Enlightenment and the history of physics, in one of his famous quotes about learning once said, "Tell me and I forget. Teach me and I remember. Involve me and I learn" Benjamin Franklin Quotes (2018). Therefore, doing virtual laboratories give students opportunities to get involved in lessons taught and thus learning is achieved. It is believed that using technology to do experiments might be the answer to the few uncertainties and unanswered questions mentioned above. For example, through the use of technology students might be able to connect to the real world and also keep engaged in lessons. Similarly, technology might help in breaking down complex chemistry lessons which makes understanding easier for students. And a computer simulated laboratory would be less tedious than a real laboratory.

Web-based and computer-simulated activities may help increase student exposure to chemistry knowledge and play a crucial role in motivating and engaging students as well as preparing them with 21st-century skills. Computer simulations are distinguished by unique sorts of interactions, that responds to users' behaviors and actions. Computer simulations offer a distinctive level of interaction. Hence, these simulations are considered to be a new model of computer-based learning that provides the individual learner with a wider range of scientific vision (Andrews, 2007). This kind of educational technology provides an advanced collaborative learning that perfectly meets the educational needs and provides a high level of interaction between learners (Barbour & Reeves, 2009).

As collaboration plays a significant role in work environments, it's important for teachers to give students the opportunities and training necessary for them to practice it. Brown, Collins, and Duguid (1989) suggest that students need to work together in order to develop a deeper understanding of knowledge. Furthermore, in the real-world, collaboration reflects the way experts work and similarly reflects the way in which knowledge is shared within communities Duffy and Cunningham (1996). There are few occupations where people do not work together to achieve goals. Teamwork plays a huge role in student learning (Gasen & Preece, 1996). It is assumed that teamwork is important because many student will join team building projects in different working sectors. It should be noted that working together in team building projects can be very challenging for many students and young employees so it’s important the teachers may be critical of teamwork as they prepare students to real life experiences.

Collaboration is a dynamic, social process that goes well beyond coordination of separate efforts (Adams & Hamm, 1990). It involves working with others, sharing ideas of new and existing concepts. Issues of group dynamics are critical to the success of any collaborative learning project (Shrage, 1990). It is important to encourage students setting goals and aiming for those goals. Student-to-student interaction and participation are some of the framework. Such activities can enhance student motivation and attitude towards learning (Hamm & Adams, 1992).

As educators seek to expand options for teaching and learning in the digital age, many have found it surprisingly challenging to choose the best tools for their students that will both maintain the clarity of classroom objectives and expectations and keep students highly engaged. Roschelle and Teasley (1995) characterize collaboration as; learning occurs socially as the collaborative construction of knowledge. The emphasis is that different individuals are involved in many activities and that these activities may create interactions that engage them. However these activities are not individual even though the main focus might be on development of individual skills. Furthermore, participants do not work individually or develop individual skills but rather the presence of other individuals in a group is paramount to other individual development.

Alternatively, a group of students might use a computer to browse through information on the Internet and to discuss debate, gather and present what they found collaboratively. This pedagogy where learning takes place via social interaction using the computer or the internet is referred to as Computer-Supported Collaborative Learning (CSCL) (Stahl, Koschmann, & Suthers, 2006).

Learning through simulations and learning by collaboration are both at the bottom of Dales' cone of learning. Edgar Dale's research from the 1940s suggests that the best method for active learning in the classroom is at the bottom of the cone, and consists of fieldwork, hands-on activities or situated learning. As Dale puts it "Do the real thing", don't read about it or listen to someone else describe it. Conversely, the least effective methods are at the top of the cone and consist of listening to presentations in a classroom or lecture hall or reading about something in a book or article.

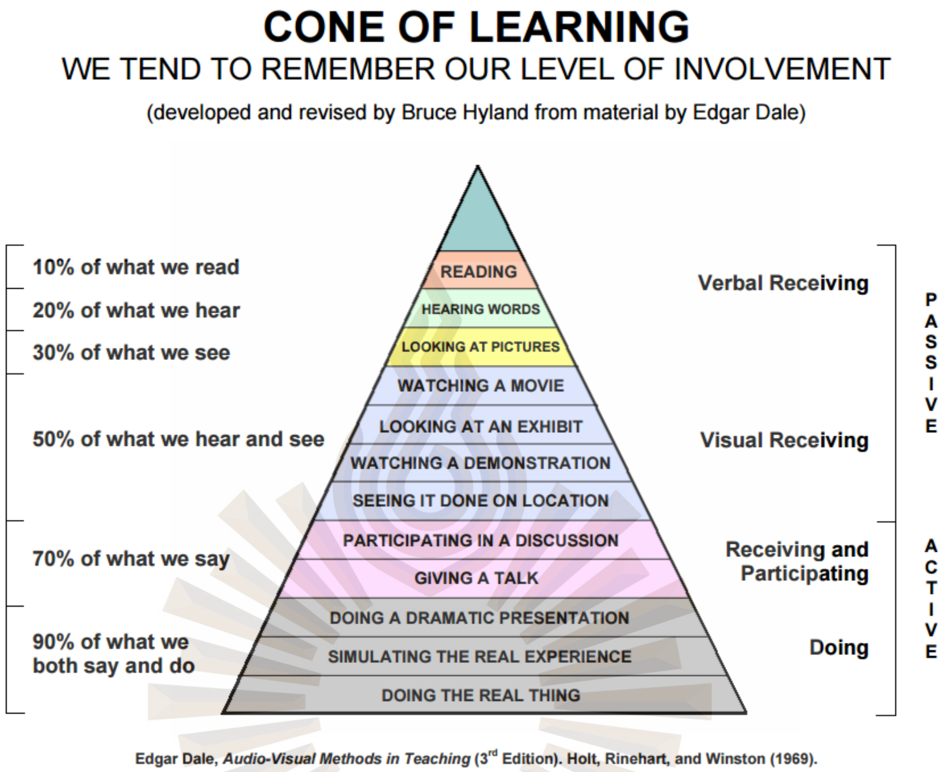

Figure 1.1 The Cone of Experience

Source: Dale, 1969

Based on Dale's research, it is believed that the use of Virtual Chemistry Labs together with Computer Supported Collaborative Learning would significantly improve students' chemistry conceptual skills.

Virtual Chemistry Labs (VCLs) are computer-based simulations with tremendous potential for applications in chemistry education. These simulations help chemistry concepts come to life in a hands-on lab environment that is shown on the computer screen. While VCLs render safety concerns and equipment needs obsolete, they encourage learners to collectively work together towards one common goal. Student interactions in virtual education can be achieved through forming groups where students work together on particular assignments, research projects, and experiments. This approach facilitates collaborative learning and in-depth discussion amongst students. Andreas, Tsiatsos, Terzidou, and Pomportsis (2010) suggested that collaborative assignments in virtual worlds are a powerful tool for achieving student interactions. Bourke (2008) suggested that collaboration around the development and visualization of 3D molecular model simulations enhanced students' understanding of these complex structures. Based on the above-mentioned researchers, the combination of VCL together with CSCL would bring not only visualization of chemistry concepts and thus a better understanding of complex chemistry topics, but also increase student interactions to achieve collaborative learning.

It should be noted that applications of VCLs have only started gaining popularity over the last decade, with around 180 virtual worlds available or under development by 2010 (de Freitas & Veletsianos, 2010). One the most successful virtual laboratories was perhaps demonstrated by the biosciences lab at the University of East London (Cobb, Heaney, Corcoran, & Henderson-Begg, 2009) In their breakthrough, Cobb et al, (2009) created a Polymerase Chain Reaction (PCR) experiment in a virtual environment; their remarkable results are discussed in the next chapter. This example shows that if the virtual laboratory is well designed, it can enhance active learning experiences and therefore increase understanding and retention of the concepts.

Figure 1.2 below is a VCL flame test workbench' which is an example of an active learning piece that keeps students engaged throughout the entire experiment. On the top right, there is a stock room where students can find the procedures for various experiments, as well as the appropriate chemicals for those experiments. Above the periodic table, there is a guide that students can select if they need help with instructions, chemicals, or using an electronic lab-book.

Figure 1.2 VCL Flame Test Workbench

In this research, the values of using VCL together with CSCL as tools for enhancing students' learning achievement and engagement in chemistry will be assessed. This research is intended to measure the students' learning achievement and engagement by the use of computer simulations VCL together with CSCL. By the end of the study, students' learning achievement and engagement in learning chemistry are expected to increase.

1.2 RESEARCH OBJECTIVES

1.2.1 To compare the students' learning achievement using VCL together with CSCL to Real Labs(RL).

1.2.2 To investigate the students' learning engagement using VCL together with CSCL.

1.3 RESEARCH QUESTIONS

1.3.1. Do students using VCL together with CSCL perform better than those using RL?

1.3.2. Are students using VCL together with CSCL engaged in learning?

1.4 RESEARCH HYPOTHESIS

1.4.1. The application of Computer-Supported Collaborative Learning in VCLs improves students' learning achievement.

1.4.2 The use of computer simulations such as VCLs keep the students engaged.

1.5 SCOPE OF THE STUDY

1.5.1 Location of the Study

A private bilingual school in Pathum Thani was chosen as the location for this study. Lessons for both groups were conducted in the chemistry laboratory. The periodic table was the topic taught during this research.

1.5.2 Population and Sample of the Study

This study was carried out in a small private school in Pathum Thani. The selected population for this study was grade 10. There are only two sections of grade 10 with a total of 40 students. Each section contains 20 students.

The sample of the study, in this case, was the only these two grade 10 sections available. The experimental and control groups were chosen randomly.

1.5.3 Content of the Study

Both groups learned about the periodic table, using flame tests to identify elements. In the control group, students worked individually in a traditional setting (Real labs) to identify the elements and their characteristics while the experimental group students worked with computer simulations (VCL) collaboratively to attain the same results.

1.5.4 Time frame

The study took approximately one month between June and July during the first semester of the academic year 2017. Both groups were taught in a double period lasting for 120 minutes.

1.5.5 Variables

There are two variables; independent and dependent variables. Computer-supported collaborative learning (CSCL) together with virtual chemistry labs (VCL) was the independent variable whereas the students' learning achievement and engagement were the dependent variables. Figure 1.1 explains both variables used in the study.

Dependent Variables **Independent Variable**

Learning Approaches

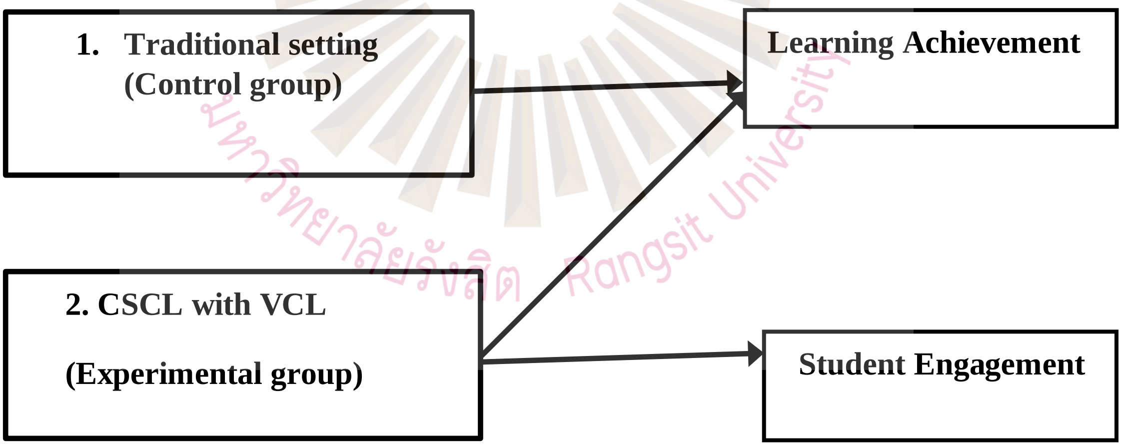

Figure 1.3 Independent and Dependent Variables

1.6 LIMITATIONS OF THE STUDY

1.6.1 The study focused on the use of computer-supported collaborative learning method only in a section of tenth grade in one of the schools in Pathum Thani Thailand. Therefore, the findings cannot be generalized to the performances of all the tenth-grade students in Thailand.

1.6.2 The content in this study was limited to only one topic from the 10th-grade chemistry which was the periodic table; therefore the findings shouldn't be generalized to other topics in chemistry nor other subjects.

1.7 OPERATIONAL DEFINITIONS

Virtual Chemistry Lab: Virtual chemistry lab refers to interactive simulations in which students perform a chemistry experiment on a computer screen.

Computer Supported Collaborative Learning: Computer-supported collaborative learning is a learning strategy that involves students working together in small groups. Since its computer-supported learning, each group of students needs the assistance of a computer to complete a given task.

Learning Achievement: Learning achievement refers to students' score in the achievement tests. It is the learning achievement of the students who were taught using virtual chemistry lab setting together with computer-supported collaborative learning and real lab setting. The participants in the experimental and control group are administered with pretest and posttest before and after the experiment respectively. The mean and standard deviation of the scores of both the tests would be then compared. The participants in both the groups should display higher mean and standard deviation in the posttest compared to pretest. But the experimental group should display significantly higher mean and standard deviation of posttest compared to the posttest of the control group.

Real Lab: Real labs refer to hands-on practices of doing science experiments in a laboratory. In this research, chemistry experiments will be specifically in practice.

Engagement in Chemistry: Refers to the level of commitment, interest, participation, behavior, interaction, and passion the students show in learning chemistry as a subject.

1.8 SIGNIFICANCE OF THE STUDY

1.8.1 The use of virtual chemistry labs together with computer-supported collaborative learning in the study enhanced children's learning achievement in chemistry

1.8.2 The study showed the use of virtual chemistry labs together with computer-supported collaborative learning and their impact on student engagement.

1.8.3 The study allowed teachers to explore new exciting opportunities for Computer Supported Collaborative Learning in a virtual chemistry laboratory.

CHAPTER 2

LITERATURE REVIEW

This chapter presents a review of the related literature to provide theoretical background of the current study. It includes concepts of real labs, virtual chemistry labs, and computer supported collaborative learning.

2.1 REAL LABS

The National Science Education Standards (National Research Council [NRC], 2011) and other science education literature, emphasize the importance of rethinking the role and practice of laboratory work in science teaching. Doing experiments requires inquiry; learners start by asking questions and finding ways or methods of answering those questions. This way, they are not simply stating facts or just listening to lectures, and giving expected answers. During labs, students are guided by the teacher to investigate, explore and discuss science procedures. Pratt and Bybee (2013) suggest that this inquiry mind in science laboratories, gives opportunities to students to master central conceptual and procedural knowledge and skills in science. Hofstein and Lunetta (2003) emphasized that the principal focus of laboratory activities should not be limited to learning specific scientific methods or particular laboratory techniques; instead, he emphasizes that it's best if students use methods and procedures that would help them to investigate scientific problems and pursue an inquiry mind.

It is believed that while laboratory investigations offer important opportunities to connect science concepts and theories discussed in the classroom and in textbooks with observations of real-world phenomena and systems, laboratory inquiry alone is not sufficient to enable students to construct the complex conceptual understandings of the contemporary scientific community. It was reported by Van den Berg, Katu, and Lunetta (1994) that hands-on activities with introductory electricity materials in studies with individual students assisted their understanding of relationships among circuit elements and variables. Tests of validity and subject's ideas were the main focus of the activities. "Frequently they led to cognitive conflict. However, the carefully selected practical activities alone were not satisfactorily enough in developing a fully scientific model of a circuit system." These findings suggested that greater engagement with conceptual organizers such as the integration of technology could have resulted in the development of more scientific concepts in basic electricity.

2.2 TEACHING AND LEARNING CHEMISTRY WITH TECHNOLOGY

Technologies have been part of teaching and learning for centuries. As the types of technologies have changed over the years, so, too, has their importance to the teaching and learning process (Cennamo, Ross, & Ertmer, 2014). They also claim that technology will not replace teachers but rather the role of the teacher will change over time and the teachers will benefit from having powerful tools and ample resources available to support their teaching. Cennamo et al. (2014) further suggest that new technologies make it easier to incorporate new learning theories and pedagogies such as active learning, knowledge construction, cooperative learning, and guided discovery in our classrooms. Notions such as "teachers as facilitators" or "students as active learners" can be implemented with the assistance of new technologies.

Teaching, learning and technology work together to achieve the ultimate goal of effective knowledge transfer (Lever-Duffy & McDonald, 2007). When teaching and learning are considered in a holistic system, all elements of the process can begin to make sense, from the learning environment and teaching strategies, to learning activities and support technologies. Figure 2.1 below demonstrates these relationships.

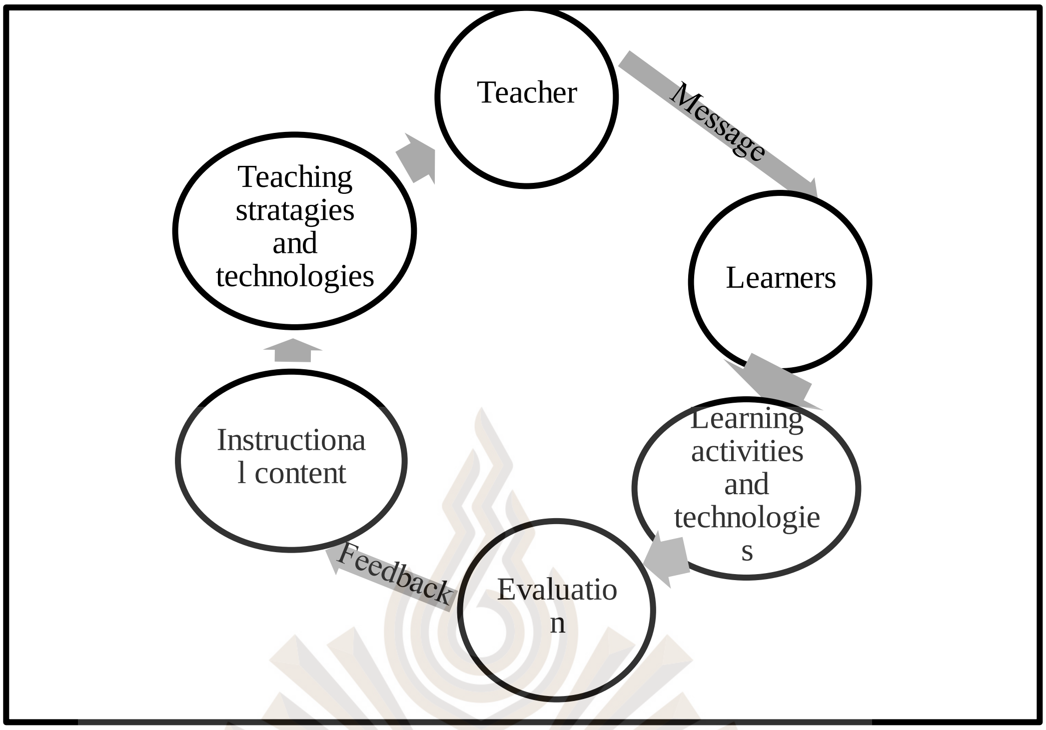

Figure 2.1 A holistic View of Teaching, learning, with Technology

Source: Adapted from Lever-Duffy & McDonald, 2007

The holistic system approach in figure 2.1 above gives the teacher a perspective needed to effectively apply each aspect of instruction to the creation of a meaningful teaching and learning process. However, according to Lever-Duffy & McDonald (2007), educational technologies cannot be selected or implemented until the teaching and learning process they support has been planned in detail by the educator. Moreover, Gess-Newsome and Norman (1999) implied that the role of a teacher besides the knowledge of a particular subject matter topics, include understanding learner's issues and problems and how they can be organized and adapted into their diverse interests and abilities and then presented for instruction.

In deciding to use technology in science teaching, it is fundamental to decide where technology can help students learn or help the teacher teach. According to McCrory (2008), two considerations should be made while choosing technologies for teaching science: (a) identifying parts of curriculum that are hard to teach where technology might help overcome pedagogical or cognitive difficulties, and (b) identifying topics in the curriculum for which technology is an essential element of the science being taught. These considerations are not trivial, and they define two kinds of technology use: pedagogical and scientific.

Furthermore McCrory (2008) points out the ways in which technology could be pedagogically useful in teaching science including but not limited to:

1) Stimulating time through simulations of natural events.
2) The usefulness of data collection methods in saving time.
3) Seeing unseeable things (for example through models and simulations).
4) Recording hard to get data.
5) Organizing hard to organize data.
6) Sharing information.
7) Accessing real time data and information.

The teacher needs to know, with respect to the particular subject and students, where technology could solve a pedagogical problem that she faces. For example McCrory (2008) suggests that biology teachers face problems like not being able to learn from dissecting real animals. This may be due to some students being repulsed by dissection and therefore not being able to engage in this activity. Those who are able to engage may make a mess of it and fail to learn the intended lessons about animal biology. The use of technology could be seen as a viable solution to replace real dissection with virtual dissection.

Another example of technology application is the Centre for Computing in the Humanities at King’s College London. A Master’s Degree in Digital Culture and Technology is offered and it attracts thousands of students from around the world. In a non-compulsory module called Applied Visualization, students study some of the significant examples of computer-supported, applied visualization-past, current and emergent – in learning and research contexts, including a variety of technologies, approaches and methods and, working under the guidance members of King’s Visualization Lab (KVL). In June 2007, KVL started the work on its first major, teaching and learning projects in second life, Thatron3 (Child 2009).

Virtual laboratories are not a new technological concept and they have been discussed in literature for almost two decades (Cobb & Frazer, 2005). However, their applications have only started gaining popularity over the last decade, with around 180 virtual worlds available or under development by 2010 (de Freitas & Veletsianos, 2010). One the most successful virtual laboratories was perhaps demonstrated by the biosciences lab at the University of East London (Cobb et al., 2009). In their breakthrough, Cobb et al. (2009) created a Polymerase Chain Reaction (PCR) experiment in a virtual environment. PCR is designed to amplify DNA for use in molecular biology, biotechnology, and forensics. The experimental group performed this procedure in a virtual environment while the control group performed it in a traditional lab setting. Their results revealed that 92% of the students requested that more experiments be done in a virtual environment. Their results also revealed that both groups improved their exam grades. However students in the virtual environment required less time and less teaching assistant intervention.

2.3 VIRTUAL LABORATORIES AND STUDENT DEVELOPMENT

Lim (2009) research suggests six basic learning environments within a virtual world:

1) Learning of exploring: students relate to different analytical tasks by relating to different simulations.

2) Learning through collaboration: collaborative problem solving and discussion based inquiry provides students with excellence in a subject.

3) Learning by being: things like role-play and performance help students explore and identify life.

4) Learning by building: building or scripting (programing) for tactile learners involved in math, physics, aesthetics, and others.

5) Learning by championing: students in real life emulate a service-based approach to learning.

6) Learning through expressing: activities that allow students to author blogs, podcasts, machinima (cinema in virtual worlds), and posters are examples of representing real-world problems.

Although all these learning support may vary from one type of learner to another, Lim (2009) suggests that different student learning styles can be stretched and development can be recognized. Modern 3D virtual worlds like VCLs are capable of providing reading material, apparatus, chemicals, and procedures for carrying out experiments all enhancing students' conceptual skills.

2.4 VIRTUAL LABORATORIES AND STUDENT ENGAGEMENT

Student engagement is a "student's willingness, need, desire and compulsion to participate in, and be successful in, the learning process promoting higher level thinking for enduring understanding" (Martin, 2008). Students who are actively engaged are more motivated to complete tasks successfully, are more focused on the task at hand, ask follow-up questions more often, are willing to try and take risks, and more often take part in rich, content-based discussions with their peers.

Hudson and Degast-Kennedy (2009) demonstrated student engagement in their experiment that involved the creation of a Canadian border simulation (see figure 2.2). In this experiment there were 3 groups of participants: (a) students that were engaged and active (participated hands on in the simulation), (b) students that emulated passive learners (observed the simulation but participated in discussions on later stage, and (c) students who acted as volunteers (these were travelers that passed through the border crossing). The simulation recreated the interview process, the necessary documents for travelers and determination of entry into the country. The volunteers were allowed to use different emotions so that the crossing guards could obtain all the necessary information that could help them allow them to cross the border or withhold them. The results of this impressive creation indicated that the students gained real life experience where a real scenario would not be possible, and also developed key interview skills. Post-class interviews revealed that students were highly engaged and that satisfaction in the learning experience was achieved. More importantly, those who actively participated achieved remarkably higher exam grades than those who did not.

Figure 2.2. The Border Crossing Simulation from Loyalist College. The setting allows students to role play as crossing guards and to experience the reactions of those passing through the crossing Hudson & Degast-Kennedy (2009).

Source: Hudson & Degast-Kennedy, 2009

2.5 COMPUTER SUPPORTED COLLABORATIVE LEARNING (CSCL)

The concept of collaborative learning has been researched extensively and is generally regarded important for critical thinking, student satisfaction, learning improvement and performance (Gokhale, 1995). Collaborative learning involves a small group of learners working together on problem-solving tasks. This may also involve the extensive use of interpersonal skills (Alvi, 1994; Dillenbourg, 2008). This concept, is based on grounds of effective learning, without excluding active learning and the construction of knowledge (Wittrock, 1978); cooperation and teamwork (Glaser & Bassok, 1989); and, learning "by doing" (Massey, Ramesh, & Khatri, 2006).

The increasing pace of technological change, globalization, and shifts in public policy has bred a stiff and competitive business environment. Employees have had to learn a more efficient rate of keeping up with the rapid changes in the competitive business environments than ever before. Computers have become important tools in this century, governments of various countries have set goals to enable increase students to access computers and the Internet. Students learning together in small groups is also something that has become increasingly emphasized in science learning in many countries. However, the ability to combine these two ideas (computer support and collaborative learning, or technology and education) to effectively enhance learning remains a challenge.

The search for study of applications of the computer in language teaching and learning (Levy, 1997) under CALL (Computer Assisted Language Learning), has been the most common technology since the integration of technology with teaching and learning. Tools such as a chat, e-mail, discussion forums, and instant messaging are today commonly exploited by educators. These tools were not created to teach language but have proven to be very effecient in helping students learn languages due to the communicative and collaborative interactions they provide (Bruckman, 2001; Soloway et al., 2000).

Currently, according to Sherman and Craig (2003), the highly interactive and multi-sensorial computer-generated 3D environments in virtual reality involve relatively new technologies that may have significant applications in the area of CALL. Apart from CALL, CAI (Computer Assisted Instruction), ITS (Intelligent Tutoring Systems), and, Logo-as-Latin are among other antecedents of CSCL (Computer Supported Collaborative Learning). However, according to Koschmann (1996), CSCL research is grounded on a very different concept of learning, pedagogy, research methodology, and research questions than all the above technology based learning theories.

2.5.1 CSCL BACKGROUND

It is difficult to predict when CSCL emerged not as a separate field of study nor as an emerging paradigm of educational technology. The first CSCL workshop took place in 1991 (Koschmann, 1994), and the first international CSCL conference was held 1995 in Bloomington, Indiana. Partly, the research on Computer-Supported Cooperative Work (CSCW) ignited the inspiration of CSCL. Galegher, Kraut, and Egido (1990); Greenberg (1991) revealed the concerns collaborative work the support of a groupware provides. Thus, in a sense, CSCL is the younger sister of CSCW. Additionally (Koschmann, 1999), suggests that linking research on learning and working more closely to each other, as well as the research on the CSCL and CSCW would be beneficial.

2.5.2 CSCL CONCEPTS

According to Resta and Laferriere (2007) the use of technology provides four instructional motives to support collaborative learning:

1) It provides learners with knowledge for the society (collaboration skills and knowledge creation)

2) It enhances learners' cognitive performance and facilitates a greater understanding.

3) It provides flexibility of time and space necessary for collaborative learning

4) It encourages learner engagement and keeps track of learners' collaborative work.

When Rochelle and Teasley (1995) wrote about collaboration in their research, they stressed that the role of shared understanding is "a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (p.70). For a successful collaboration framework, the material world provides a very important role in coordination of play activities which lifts the children's symbolic play. The impact of using materials to facilitate understanding shared goals through collaboration is neglected by most theories and approaches. However computers do offer a rich selection of anchors to reference to, and points of shared reference (e.g. simulation on a screen). According to Crook (1998), there are three features of interaction that are central to successful collaboration: intimacy among participants, rich supply of external resources, such as computers, lastly histories of joint activity of those interacting.

Vygotsky (1978) highlights the roots of collaboration in his social learning theory specifically, CSCL corresponds to Vygotsky's theory in the notion of internalization, or the idea that knowledge is developed by one's interaction with one's surrounding culture and society. Since Vygotsky emphasized the critical importance of interaction with people, including other learners and teachers, in cognitive development, under the theory "social constructivism", much of the collaborative problem solving strategy is built on his best known idea of the zone of proximal development (ZPD). This refers to the ability of skilled individuals like teachers providing assistance for learners to master tasks that would be impossible to master by themselves These ideas feed into a notion central to CSCL: knowledge building is achieved through interaction with others.

2.6 EMPIRICAL RESEARCH ON CSCL

In contrast to its predecessors that studied human cognition with experimental design and in laboratories, CSCL research is conducted also in "real world contexts", for instance, at schools. For example, Dillenbourg (2008a) suggested that one should specifically talk about the effects of particular categories of collaboration rather than the general effects created by the interaction of collaborative learning. For example, it's important that one analyzes which interactions actually did take place during collaboration as suggested by Dillenbourg (2008b). Another example is from Stahl (2008) research that explored studying the sequences of improvement and refinement of ideas, and focusing less on individual statements in discourse. In other words, one should in collaborative interactions zoom in more intensively on the micro level.

Additionally, analyzing collaboration at a micro level is perhaps to think about communities as interaction networks, and interactions representing strong and weak links among participants. We may assume, as pointed out by Wellman and others (Wellman et al., 2000) that intensive and productive collaboration can be presented by strong links and intensive interactions between community members. Furthermore, we could speak about computer-supported social networks. Or, the unit of analysis could be, as proposed by Engestrom (2012) an activity system.

It is rather an impossible task to compare empirical studies conducted under the label CSCL, because they are different in many ways. First of all, there are no restrictions to what one should study; effects of or effects with CSCL. In 1991, Salomon, Perkins, and Globerson produced two thinking aspects for educators about learning and teaching with technology. According effects *of* technology deserve a closer look, thus paying attention to what one has learned and should infer from those situation working with computer. On the other hand one should also look at the effects *with* technology; thus what one could achieve in synergy with a computer as opposed to without. Similarily, one should speak about effects *of* CSCL; or, by contrast, one may speak of effects *with* CSCL.

Researchers have used different learning tasks to analyze learning in CSCL, and have studied how special concepts are learned (Roschelle, 2013). They have analyzed socio-cognitive effects of CSCL (Hakkarainen & Lipponen, 2002), the collaborative construction of chronotopes during computer-supported collaborative tasks (Ritella, 2012), explored social practices of CSCL and collaborative learning at CSCL (Stahl & Hesse, 2006, 2013), collaborative knowledge building (Lipponen, 2000), examined students' participation in authentic proof activities in CSCL environments (Oner, 2008), and designed CSCL processes (Seitamaa-Hakkarainen, Raami, Muukkonen, & Hakkarainen, in press). Lately, stress is also put on issues of online collaboration (Balakrishnan 2014). These are just few of the research topics that have emerged in the context of CSCL.

Previous research regarding CSCL has been conducted using a variety of technologies, objectives and applications. Research questions that have been explored include: Is students' collaboration supported around the computer (for instance, with simulation programs), or is it supported with networked learning environments, and is technology used for structuring the collaboration or to mediate collaboration (Dillenbourg, Eurelings, & Hakkarainen, 2001; Oner, 2008; Stahl & Hesse, 2013). There has been a wide range of methodologies and instruments used as well.

The boundless enthusiasm towards technology has made researchers mainly focus on the potentials of CSCL. In some aspects this has resulted in consideration of the potentials of technology and collaboration as empirical evidence for the actual benefits of CSCL. Some studies have had success in promoting high-quality learning supported with computer networks (Stahl & Hesse, 2006). However, there is no solid evidence that collaboration provides remarkable learning results. Stahl (2008) even suggests that CSCL environments are built for view exchange of their users. They could also be used more frequently for supplying surface knowledge but not for creating collaborative knowledge building. In addition, control conditions lack in many CSCL environments and as a result this leads to speculation that some of these CSCL results could possibly be achieved without any computer support.

Among other constraints on the dominant research in CSCL is that there is little research on students participating in collaborations that are networked, as well as the consequences of the different types of participation patterns, and the relationship between these aspects and the CSCL, (Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2001). Consequently, due to the ambiguity of the empirical studies in the CSCL research, it is difficult to make any solid conclusions whether it's a particular approach, an instructional method, or application that would give better results. In fact one cannot know the exact the circumstances in which the results can be extended from one context to another.

2.7 ADVANTAGES AND CHALLENGES OF CSCL

The abilities for learning provided by technology are different from those provided by other contexts. Research has revealed several benefits of computer use for collaboration;

1) First but foremost, computers eliminate time constraints by providing a break-down of physical and temporal barriers of schooling.

2) Students can reflect to their writing by providing visualization of their pieces.

3) Students with varying knowledge and competencies can share interactions and thus offering multiple perspectives and Zones of Proximal Development (ZPD)

4) Sharing and seeking knowledge can be achieved.

5) Furthermore, the computer database can serve as a memory for continuous learning and reflection.

On the other hand, CSCL has slowly adapted**.** As proposed by Kling (1991) in the context of CSCW, collaboration might be surrounded by a lot of biasness that interpretation of its benefits is so narrow. This may limit one from seeing that collaboration cons. For collaboration to be more realistic, all these issues should be taken into account. In fact, Stahl and Hesse (2013) explored the different ways of overcoming the difficulties associated with computer-supported collaborative learning. There are other challenges of CSCL: knowledge management problems with large databases, fact oriented knowledge construction, short discussion threads with divergence topics, and unequal participation patterns (Guzdial & Turns, 2000; Lipponen et al., 2001).

According to Stahl (2008), some of the weaknesses of computer-supported collaborative learning environments are personal and cultural reasons, and that this creates fear for students and teachers to use them. Additionally, if the technology is used excessively, there still might be issues of proper collaboration and knowledge construction.

2.8 PREVIOUS RESEARCH OF CSCL WITH VIRTUAL LABORATORIES

Research by Lin (2001) reveals that creating learning communities and providing supports are the most two essential pedagogical issues for the success of learning in a virtual environment. Similarly, Geer and Barnes (2007) suggested that due to the increasing development in various technologies, educators face a dilemma in choosing the best technology that would support their teaching goals.

Similarly due to the lack of knowledge of all these new technologies together with lack of pedagogical guidance about integrating them to produce the most useful collaboration and communication, educators are often left confused about which technology-based resources are effective for given pedagogies and learning expectations. Additionally, the failure to assess the difficulties of collaborative activities and their cognitive processes operating within virtual learning environments inhibits the design of effective CSCL environments**.**

Wu and Koszalka (2011), explored the best example of a Collaborative Engineering Design (CED). This course was created to engage distributed teams of engineering students working in virtual laboratories. The virtual laboratories incorporated tools that engaged learners with a variety of methods that supported collaborative engineering design tasks. Moreover, learners managed to use a variety of communicative and analysis tools in a virtual laboratory. They were also able to share ideas and explore solutions.

2.9 RELATED LEARNING THEORIES

2.9.1 Dales Cone Theory

Dale's Cone of Experience is a model that incorporates several theories related to instructional design and learning processes. According to Edgar Dale, learners can retain more information by what they "do" as opposed to what is "heard", "read" or "observed". Because of Dale's research, the Cone of Experience as developed. The Cone was originally developed in 1946 and one of its many intentions was to describe various learning experiences. Basically, the Cone represents a series of experiences from the most concrete (at the bottom of the cone) to the most abstract (at the top of the cone) as seen in figure 1.1.

According to one of the principles in the selection is that the more the senses are involved in learning, the deeper the understanding will be. To achieve a better and understanding of all the learners' domain development, a balance must be created between the stages in the experience. This is necessary in order to help each learner in their holistic development.

It should be noted that Edgar Dale’s cone is not a perfect model; it is however a merely visual that helps to explain the interrelationships of the different types of audio-visual materials. It also provides individual positions in the learning process. According to his model, Dale describes the use of words as the modest way of learning, at the top of the cone and real-life experiences the most practical way of learning, at the base of the cone.

2.9.2 Dewey’s Experiential Learning Theory

In John Dewey's experiential learning theory, everything occurs within a social environment. John believed that knowledge is socially constructed and based on experiences. This knowledge is an image of real world problems, experiences that are realistic and practical. According to Dewey, the teacher's role is to organize this content and to facilitate the actual experiences.

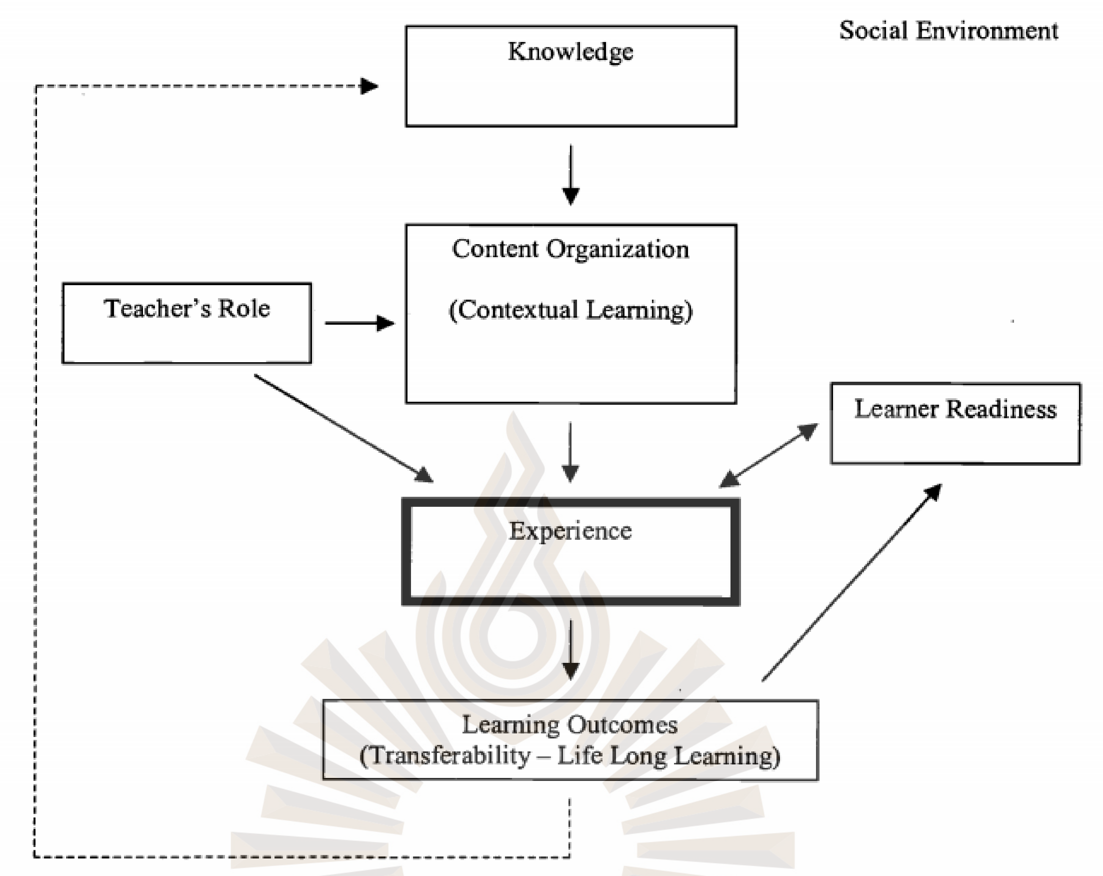

Figure 2.3 Conceptual Model of Dewey's Philosophy of Experiential Education

Source: Roberts, 2014

In the model above is enclosed within a box that represents the social environment. The model begins with knowledge, the teacher organizes this knowledge into logical content pieces. Also when the teacher has prepared the students for these real life experiences then he can facilitate the appropriate activities. As a result of experience, not only learning can be achieved but also, the learner readiness and knowledge, thus allowing the process to begin again.

Dewey emphasizes that the development of mankind into complex units is enhanced through social interactions. Dewey further asserts that people live in a world surrounded by people and other things that are a result of previous human experiences. Living together and the social interactions experiences construct knowledge as we know it.

Education is critical to the social nature and interaction of mankind. "The principle that development of experience comes about through interaction means that education is essentially a social process" (Dewey, 1938, p. 58). However, sometimes education does not understand the value of the social nature of students. Dewey argues that schedules, procedures, and principles provided by the traditional education inhibit student learning. However, in Dewey's Progressive Education, he argues that there should be careful planning should be included in the nurturing of social relationships.

In this theory Dewey explains that knowledge results from the learners' experiences. The past is not the end of education; it is merely a means to help teach about the present. In traditional education, the teachers organize the content which is often outside the scope of learners. Dewey argues that this external control should be rejected. The true source of educational control is found within the experience of students.

Dewey's experiential learning theory highlights the role of the educator as a facilitator that organizes appropriate experiences that engage students. In experiential learning, "the teacher is no longer a dictator but becomes a leader of group activities" (Dewey, 1938, p. 59).

Experiential learning often has considerable amount of student led activities. In these activities, students can explore and experience the contents of the lesson. The teacher evaluates and controls the amount of activities for learners. Those that disagree with Dewey believe that these activities are chaotic. Dewey counters that, "there cannot be complete quietude in a laboratory or workshop" (1938, p. 63) and that teacher facilitated free activities are significant to student learning.

As much as Dewey promotes experiential learning, he believes that all experiences are not educative. He uses the term mis-educative to describe experiences that interfere with learning. He believes that everything depends on the quality of the experience which is one has had (Dewey, 1938, p.27). He believes that experiences that lead out to the real world are educative experiences. Thus, experiences lead to the ability to transfer knowledge to new situations or concepts. Dewey further explains the difference between the good and bad experiences. He argues that activities that involve means and their intentions to fulfill their aims are good experiences. Therefore an educative experience must lead the anticipated educational outcomes.

2.9.3 Constructivism Learning Theory

Constructivism is a learning theory found in psychology which explains how people might acquire knowledge and learn new skills. Constructivism knowledge is constructed mentally. This approach of learning and teaching helps students to assert new information together with the old one. Constructivists believe the students' attitude towards leaning influences what knowledge they will acquire. Driscoll (2000) explains that constructivist theory stresses that knowledge can only exist within the human mind, and the fact that whether it does or doesn't match the real world id irrelevant. Learners constantly perceive their own model of what a real world looks like in their own way. As they perceive each new experience, they update their existing information continuously and will, therefore, construct their own interpretation of reality.

According to Jonassen (1994), constructivism is also often misinterpreted as a learning theory that obliges students to "reinvent the wheel." In fact, constructivism triggers the student's distinctive curiosity about the world and how things work. The theory is not a a reflection of students reinventing the wheel but, rather, attempt to understand how it turns, how it functions. By trying to understand how it turns and functions, they become engaged by applying their existing knowledge and real-world experience, learning to hypothesize, test their theories, and ultimately drawing conclusions from their findings.

Engaged learners are active learners. Phillips (1995) explains that constructive learners are active learners but not passive learner. Learners encounter a learning experience and try to understand the depth of. If what learners encounter is inconsistent with their current understanding, their understanding can change to accommodate new experience. During this process learners remain active: With their already existing knowledge, they apply the current understandings, be critical of the new learning experiences and embrace the new knowledge without being judgmental or biased. Similarly Tam (2000) believes that constructivist learning can benefit from teaching of complex skills, such as problem solving or critical thinking skills.

It is also believed that constructivism supports social and communication skills. It generates classroom environments that emphasize collaboration and interaction. During the process students must learn how to generate their own, work with others to effectively accomplish a given task. This kind of teaching and learning emphasizes students to exchange ideas and so must learn to respect others and their difference in opinions. This brings success in the real world learning experiences.

2.10 CONCLUSION

Previous studies, for example Lim (2009) highlights the roles VCL plays in student development, Alvi (1994); Dillenbourg (2008b); Lin (2001), the significance of CSCL in effective learning, Clarke and Dede (2007); Wu and Koszalka (2011) both explored how VCL and CSCL increase student interaction and engagement. CSCL provides the unique opportunity to explore and define conceptually alternative modes of computer-supported, collaborative learning that will enrich learning and working in the twenty-first century. It has the potential to close the gap between school and workplace learning by allowing learners to engage in activities requiring collaboration, creativity, problem-solving, and distributed cognition. It provides insights and alternative models of cognitive activities by illustrating what can be learned as a result of intentional teaching and what can be learned from working on interesting problems with others.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter describes how this study was conducted to answer the research questions. The research design, the population and samples, the research instruments, data collection procedures, validity and reliability, and data analysis of the current study are discussed in detail.

3.1 RESEARCH DESIGN

A quantitative research mixed with a qualitative study was used in this research. Qualitative methodology refers in the broadest sense to research that produces descriptive data – people's own written or spoken words and observable behavior. Qualitative research provides a way to approaching the empirical world. Qualitative researchers are concerned with the meaning people attach to things in their lives and hence qualitative research involves understanding people from their own frames of reference and exploring reality as experienced by the participant. (Corbin & Strauss, 2008). Furthermore, Blumer (1969) emphasized the need of qualitative researchers to empathize with and understand the people they study in order to understand how those people see things. As advised by Mason (2004), It is important for qualitative researchers not to take things for granted. Qualitative researchers should view things as though they were happening for the first time.

Figure 3.1 illustrates the procedures of this research study.

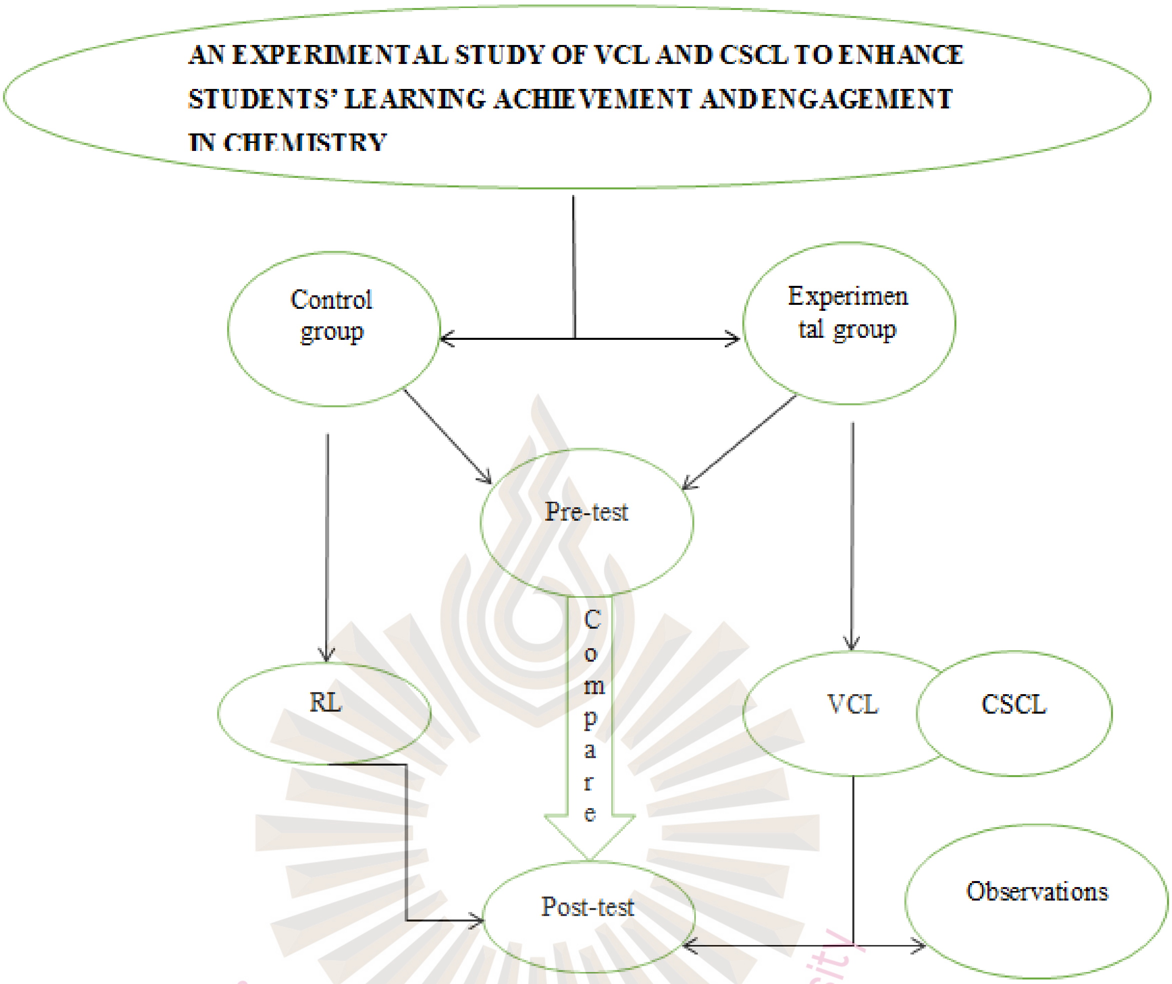

Figure 3.1 Research Design of the study

3.2 POPULATION AND SAMPLE

3.2.1 Research Population and Sample

This study was carried out in a small private school in Pathum Thani. The selected population of this study was grade 10. There were only two sections of grade 10 with a total of 40 students. Each section contained 20 students.

The sample of the study in this case was the only these two grade 10 sections available. The experimental and control groups were chosen randomly. The two groups had the same academic strength in chemistry from previous examination scores so there was no bias in choosing these groups. Also this was corroborated from their pre-test scores which were closely related.

3.3 RESEARCH INSTRUMENTS

A quantitative research mixed with a qualitative study was used by the researcher. Qualitative data was collected through pretests and post-tests whereas qualitative data was obtained from the classroom observations consequently answering research problems of this study which were to; compare the students' learning achievement using VCL together with CSCL to Real Labs (RL) and investigate the students' learning engagement using VCL together with CSCL respectively.

3.3.1 Pre-test and post-test

Data from pre-test and post-test was collected from both the control and experimental groups to measure student achievement. 40 multiple choice questions about the periodic table were prepared for the pre-test and these were given to students prior to the research. Similarly, the same questions with the same level of difficulty but interchanged and arranged differently were given in the post-test at the end of this research. The results from pre-test and post-test of both groups were assessed and then compared by the researcher.

3.3.2 Observations

Observations were used to collect information from the experimental group on how the use of VCL together with CSCL engaged the participants.

Unobtrusive observations were used where the observer simply recorded how the different participants were behaving and interacting.

To avoid bias during observations, the observer used a double-entry notebook. This type of observation log helped the observer to separate the observations (the facts) from feelings and judgments about the facts.

Descriptions of student behaviors, and interactions from the double-entry notebook and overall conclusion about classroom events were written by the researcher.

3.3.3 Lesson plans

Eight lesson plans based on Computer Supported Collaborative Learning (CSCL) theory were used to teach the experimental group. The experimental group was the group who worked with computer simulations in a collaborative manner and CSCL lesson plans were used for this group only. The control group was the group that learned using the tradition way of doing real laboratories. Both groups were taught twice a week for four weeks. Regular lesson plans were used to teach the control group. Each lesson lasted for about 50 minutes.

3.4 VALIDITY AND RELIABILITY OF RESEARCH INSTRUMENTS

3.4.1 Validity

Three experts validated the research instruments of this study. These experts included a lecturer in Education Faculty of a well-known Thai private university, and two heads of science departments in two different bilingual schools in Pathum Thani. Item Objective Congruence (IOC) of the instrument were calculated to see whether the item aligned with the learning objectives or not.

The result of the IOC index ranges from -1 to +1.

+1; the item clearly matches objectives or ensures that the following measures meet the objectives stated.

0; unclear or unsure whether the measures meet the objectives or not.

-1; item clearly doesn't match objectives or ensures that the measures don't meet the stated objectives reality (Rovinelli & Hambleton, 1977)

The formula for calculating IOC ∑r/n was used. 'r' represents the sum of score of individual expert and 'n' represents the number of experts who validates the items. If the value of test item is between 0.67 - 1.00, it is considered to be accurate and acceptable. But, if the value is below 0.67, this indicates that the item needs to be rephrased according to the expert. In this study the average rating for all test items by the three experts was 0.95. Similariy, the average rating of observations was also 0.95 and 0.94 for the lesson plans. All these values indicated that the instruments were valid for this study.

3.4.2 Reliability

Forty questions about the periodic table were developed by the researcher and they were answered by grade 10 students of another bilingual school in Pathum Thani. Students of this school were expected to be of the same knowledge level as those this research is going to be carried on. Kurder-Richardson's formula (KR-20) was computed to find out the reliability coefficient of the test items. For the instrument to be reliable, the KR-20 coefficient must be equal or greater than 0.70. In this study a 0.973 value of reliability was obtained using the KR-20 method.

3.4.3 Pilot Study

Two lesson plans based on Computer Supported Collaborative Learning (CSCL) theory, a pretest, and observations were used for the pilot study to validate the strengths and weaknesses of the instruments. The instruments were trialed with a group of thirty Grade 10 students in another private school in Pathum Thani which possesses similar attributes to the sample groups. The data was collected and kept confidential for subsequent use in revising the research instruments.

3.5 DATA COLLECTION PROCEDURES

3.5.1 Ethical Consideration

3.5.1.1 Approval

Because participants in this research were below 18 years, a consent letter was given both to the participants and their parents to sign. Similarly, the names of the participants were not revealed throughout the study.

3.6 DATA ANALYSIS

3.6.1 Test Scores

A descriptive statistical analysis was applied for the mean and standard deviation. A comparative statistical analysis using paired sample t-test was done on the 40 items of pre-test and post-test within the group i.e. analysis of pretest and posttest of experimental group as well as control group. The comparison between pretests and posttests scores of the two groups was done by conducting independent t-test. The value of 2-tailed significance value (P) was referred to determine the significance difference between the means. These results are discussed in the next chapter.

3.6.2 Observations

A core theoretical proposition that guided this study is that teaching is best understood as a multi-dimensional phenomenon in which various elements interact with one another over time but the use of a computer to carry out laboratory experiments was predicted to give even better results of interaction. Students of the experimental group were observed by the researcher how they used a computer to interact with one another and perform laboratory tasks that were given to them. The observer moved around the classroom during the tasks and coded the students' behaviors every 15 seconds according to BOSS's terminology. In this terminology, the behaviors are classified into two, engagement (on-task behavior) and non-engagement (off-task behavior). These two classifications are further subdivided into active and passive i.e. active engagement behavior or passive engagement behavior.

To analyze the qualitative data, the coding system (open. axial and selective) of the grounded theory (Corbin & Strauss, 2008) was used. The overall data was organized and interpreted under the five core themes in the next chapter.

CHAPTER 4

RESULTS AND DATA ANALYSIS

This chapter presented the demographic profile of the sample, followed by the result analysis done in two parts.

4.1 Test score analysis

4.2 Observation analysis

4.1 DEMOGRAPHIC PROFILE OF THE SUBJECTS

Total of 40 tenth grade students were divided into two groups of control and experimental. Table 4.1 shows the demographic information of the subjects.

Table 4.1 Demographic information of the subject

		Experimental Group	Control Group
Gender	Male	12(60%)	11(55%)
	Female	8(40%)	9(45%)
	Total	20(100%)	20(100%)
Age Range	15-16	20(100%)	20(100%)
	Total	20(100%)	20(100%)

Table 4.1 provides details of the sample by gender and age. The sample of both the groups consisted of 20 students each. Out of 20 students in experimental group, 12 (60%) were male and 8(40%) were female. All of the 20 students in this class, (100%) were in the age range of 15-16. In the control group, out of 20 students, 11(55%) were male and 9(45%) were female. Like the experimental group, all the students in the control group were in the same age range of 15-16 years.

4.2 ACHIEVEMNET TEST SCORE ANALYSIS

The first objective of the study was to find out the learning achievement of grade 10 students in chemistry using CSCL. The data were collected by administering pretest and posttest (Appendix B) to both groups. A comparative statistical analysis was done using paired sample t-test. The comparison was first done within the group by comparing the pretest and posttest of each group and then between the groups by comparing pretest and pretest, and posttest and posttest of the two groups. The comparison was done in terms of mean, standard deviation and significant value.

4.2.1 Pretest-Posttest Comparison (within the groups)

Table 4.2 shows the comparison of pretest and posttest of the control group.

Table 4.2 Pretest and Posttest Comparison of the Control Group

Group	Test	Mean	Mean Difference	Standard Deviation	Sig(2-tailed)
Control	Pre-test	25.70	25.75-25.70 =0.05	7.51210	0.982
	Post-test	25.75		6.64019	

Significance level (p) : 0.982-Significant > more than 0.05

Comparing the pre-test and post-test of the control group, it was found that there was no significant difference in the mean score of the students. In fact the difference was 0.05 with the post-test slightly showing a higher mean of 25.75 as opposed to 25.70, of the pretest. The post-test standard deviation was 6.64019 while that of the pre-test was 7.51210. The significance value was 0.982 which is more than 0.05, therefore the null hypothesis can’t be rejected as the mean difference is not statistically significant. This means that the student post-test and pre-test score results were slightly similar.

Table 4.3 Comparison of Pre-test and Post-test of the Experimental Group.

Group	Test	Mean	Mean Difference	Standard Deviation	Sig(2-tailed)
Experimental	Pre-test	26.65	34.25-26.65=7.6	7.85577	0.001
	Post-test	34.25		5.57131	

Significance level (p) :0.001-Significant < less than 0.05

The experimental group results showed a relatively high mean difference between the post-test and pre-test of 34.25 and 26.65 respectively. A 7.85577 standard deviation of pre-test was a higher value than 5.57131 for the post-test. Additionally the results show a significance level of 0.001 a less value than 0.05, thus rejecting the null hypothesis between means. This means that it's statistically significant and therefore it is important to note that there was a remarkable level of difference between the post-test score and pre-test in this group.

Table 4.4 Comparison of Pretests between the Control and Experimental groups.

Group	Test	Mean	Mean Difference	Standard Deviation	Sig(2-tailed)
Control	Pre-test	25.70	26.65-25.70=0.95	7.51210	0.698
Experimental	Pre-test	26.65		7.85577	

Significance level (p) : 0.698-Significant > more than 0.05

The pre-test results of both groups were slightly similar with the experimental groups achieving a 26.65 mean compared to 25.70 of the control group. A significance level of 0.698 which is more than 0.05 meant that there was no significant difference between the pre-test means of these groups. It could be argued that the students were probably at the same level prior to the start of this research.

Table 4.5 Comparison of Posttests between the Control group Experimental groups.

Group	Test	Mean	Mean Difference	Standard Deviation	Sig(2-tailed)
Control	Post-test	25.75	34.25-25.75=8.5	6.64019	0.000
Experimental	Post-test	34.25		5.57131	

Significance level (p) :0.000-Significant < less than 0.05

Table 4.5 shows that the experimental group recorded a higher mean score of 34.25 in the post-test compared to 25.75 by control group. Similarly the significance level was 0.000 which is less than 0.05 leading to reject the null hypothesis, therefore the difference in post-test and pre-test score between the experimental and control group is statistically significant. This means that at the end of this experiment, the experimental group students performed better than control group students.

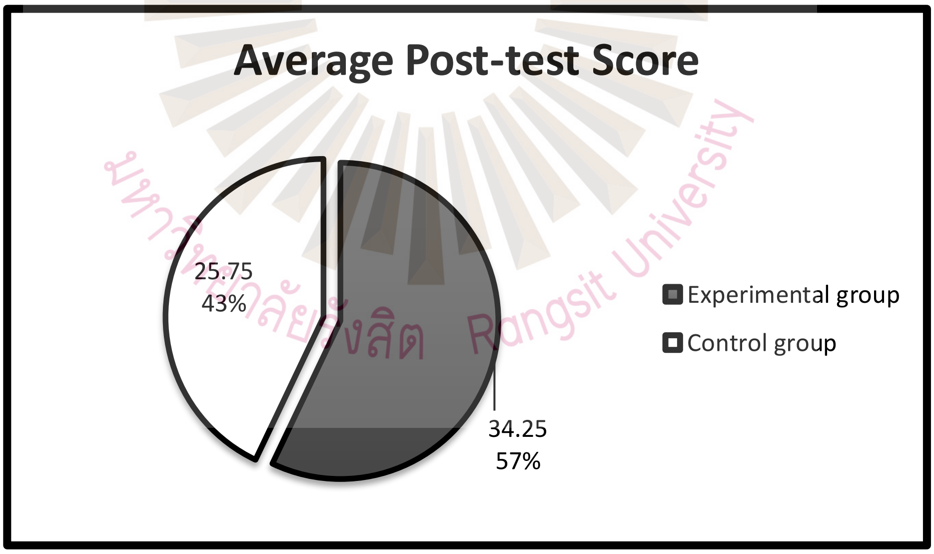

Figure 4.1 The average Post-test Score

Figure 4.1 above is a pie chart illustrating the average post-test score of students in the control and experimental groups. It can be clearly seen from the pie chart that at the end of the experiment students who learned with VCL together with

CSCL achieved a higher score (57%) on the test than those that learned in a traditional setting (43%).

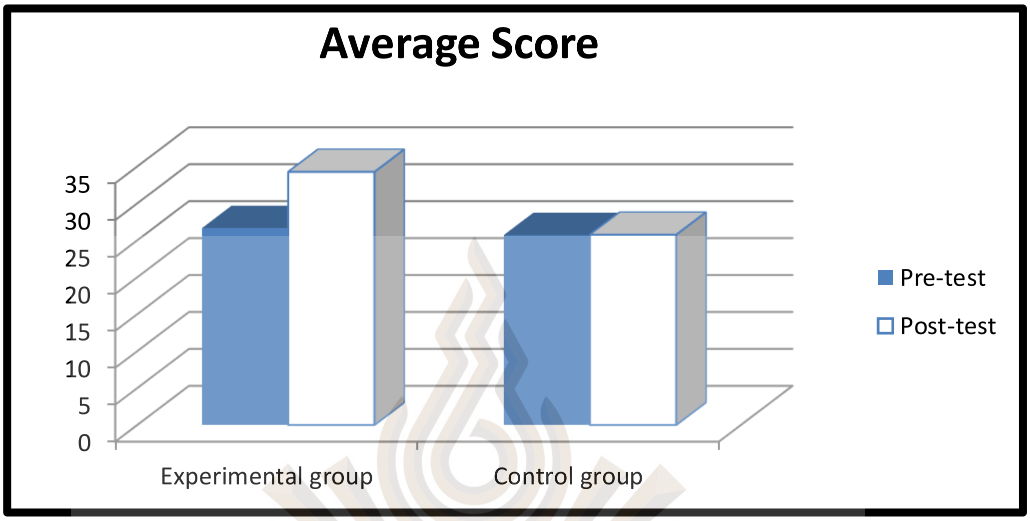

Figure 4.2 The Average Test Score of Both Groups

Figure 4.2 compares the average score from pre-test and post-test of both groups. It can be seen that the bars of the control group are almost at the same level thus the post-test score are almost similar to the pre-test in this group. On the other hand, post-test bar on the experimental group is higher than the pre-test which shows that there was an increase in average scores.

4.3 ANALYSIS OF STUDENT OBSERVATION

Another objective of this research was to make sure that students were working together in groups to complete the VCL tasks that were given to them. During this time, the researcher made notes while observing students' on/off-task behavior. Despite the fact that they were working in groups, the researcher observed each students' individual on-task/off-task behavior. The researcher constructed a coding system to describe students' on-task and off-task behavior. DeMunck and Sobo (1998), implied that it is important for researchers to construct a coding system that is a true structure of the process they are studying.

Based on the observations data, it is undoubtedly that CSCL kept the students engaged. Observations were made every 15 seconds for each student. Records of active or passive engagement behavior were made and non-engagement behaviors were recorded simultaneously. Non-engagement behavior included motor, verbal and passive off-task based on BOSS terminology.

Results revealed that students were more actively than passively engaged. At the beginning of the lesson students listened to the teacher's instruction and throughout the research they interacted with their peers, they planned and discussed the learning material and activities together. They worked on the VCL experiments together. The researcher also observed that students listened to their peers and valued their opinions they planned and executed the tasks given to them together. The researcher paid more attention to whether the students were interacting and sharing ideas about the task given but no other unrelated material on the computer. In fact, one group opened a Google search link, when the researcher asked why they were not using the VCL application at the time they said they didn't understand the meaning of certain equipment so they wanted to look up the equipment and see what it looked like. Besides this, the rest of the groups used their computers appropriately and completed the given assignments without any sort of diversion. However it should be noted that there were a few cases of off-task behavior.

Table 4.6 Off-task Students

Student	Non-engagement behavior			
A	TA	TS	LA	
B	TS	TA		
C	LA	TA	LA	LA
D	LA	LA	MN	MN
E	TT	TS		
J	LA	TA	MN	
K	TA	TT	TA	

Table 4.6 Off-task Students (Cont.)

Student	Non-engagement behavior			
L	TT	MN		
S	TT	TS		
T	TS	TT		

Table showing non-engagement behavior (motor, verbal and passive off-task)

KEY

TA: Turning his body away/ head down fidgeting in seat

TS: Touching another student

LA: Looking around room/ turning away

MN: Making noise quietly/loudly

TT: Talking at inappropriate times

Student C and student D showed off-task behavior four times. This was the most frequent from the group. Both of them looked around and turned away from the computer at least two times, Student C turned his body away and fidgeted in his seat while student D made noise two times. Other non-engagement behavior from other students included talking at times they were not supposed to talk, and touching each other. Five students were off-task only two times and three students were off-task three times. On the other hand, 10 students F,G,H,I,M,N,O,P,Q, and R were not involved in any kind of non-engagement behavior.

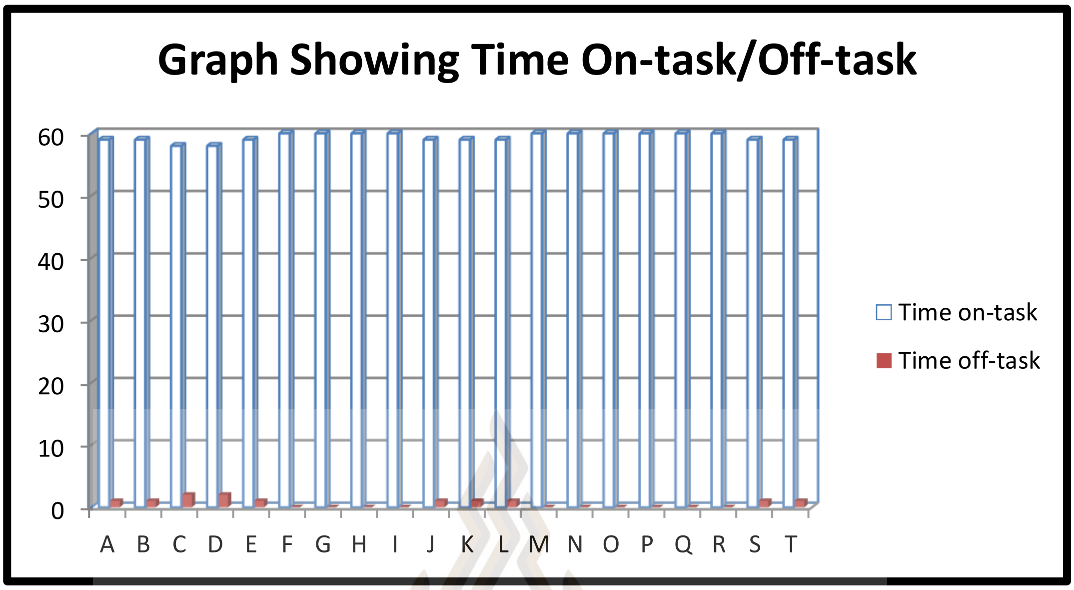

Figure 4.3 Time in Minutes Each Student was On-task or Off-task.

The graph above shows the total time the students were on-task or off-task during VCL experiments. It can be noticed that students mostly were on-task. Only two students were off-task for two minutes and eight students for one minute. A total of 10 students were 100% on task they didn't show any off-task behavior

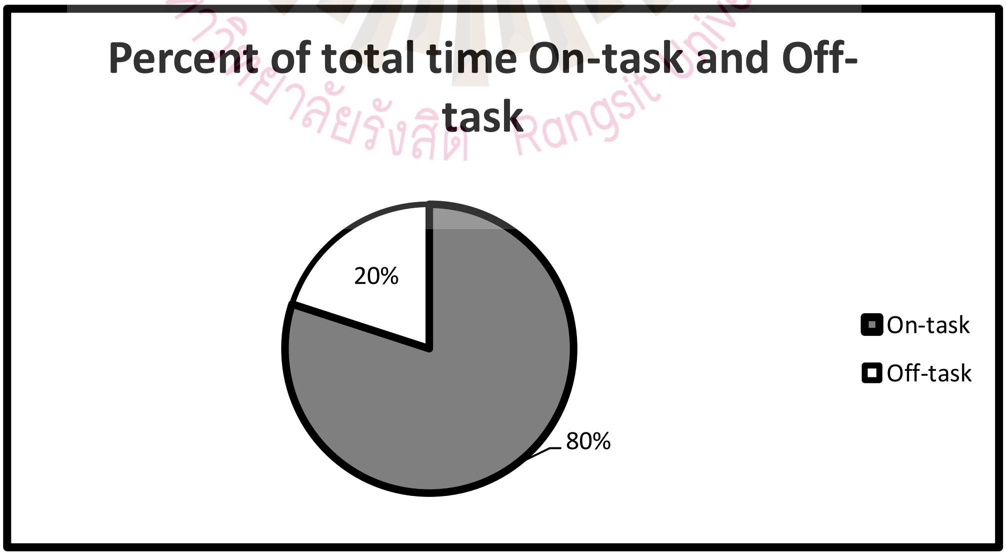

Figure 4.4 Percentage Summary of Time Spent On-task and Off-task

From the graph above it can be noticed that 20% of the time was spent on off-task behavior and 80% of the time was spent on-task meaning that VCL experiments and working together in groups kept the students engaged.

CHAPTER 5

CONCLUSION, DISCUSSION AND RECOMMENDATION

This chapter presents the conclusion from the results of data analysis, discussion of the findings followed by recommendations for practice and future studies.

5.1 CONCLUSION

The study had two objectives. The first objective was to compare the students learning achievement in VCL together with CSCL to that of RL and secondly to investigate whether students learning using VCL together with CSCL would be engaged. Quantitative data mixed with qualitative data were collected to achieve the research objectives. The following conclusions were drawn from the results of data analysis.

5.1.1 The Result of Test Score Analysis

The first objective was to compare the students learning achievement in VCL together with CSCL to that of RL. Pretest and posttest were administered to both the experimental and control groups to determine the differences in their learning achievement.

A comparative statistical analysis using paired sample t-test was done within the group. The mean of the pretest and posttest of the experimental group were 26.65 and 34.25 respectively as shown in Table 4.3. The mean of pretest and posttest of the control group were 25.70 and 25.75 respectively as shown in Table 4.2. The mean difference of experimental group was 7.6 while the mean difference of control group was 0.05. Results from the experimental group in table 4.3 show a significance level of 0.001 a value less than 0.05; this indicated that there was statistically significant increase in the scores of posttest than that of pretest in the experimental group. However a significance value was 0.982 which is more than 0.05 for the control group indicated that the mean difference in pretest and posttest was not statistically significant thus a significantly low improvement in their test score. These results prove that the first hypothesis of this research which stated that the application of Computer Supported Collaborative Learning in Virtual Chemistry Labs would improve student learning achievement was true and thus answering the first research question whether students using VCL together with CSCL would perform better than those using RL.

5.1.2 The Results of Student Observations

The second objective of the study was to investigate whether student learning using VCL together with CSCL were engaged. The researcher made observations to complete this objective. Results revealed that students were more actively engaged. At the beginning of the lesson students listened to the teacher's instruction and throughout the research they interacted with their peers, they planned and discussed the learning material and activities together. They performed the VCL experiments together. The researcher also observed that students listened to their peers and valued their opinions they planned and executed the tasks given to them together. Two students were off-task four times, three students three times and five students only two times. On the other hand, 10 students were not involved in any kind of non-engagement behavior. Out of 20 students, 10 students showed no off-task behavior meaning they were completely engaged into the tasks given during the lesson and those that showed off-task behavior it was not frequently done. The most being only 4 times by two students throughout the entire lesson, even with this kind of behavior, these students spent most of the lesson time on-task. Therefore it can be concluded that students that learned in VCL together with CSCL were engaged thus the observation results strongly supported the second hypothesis of this research.

5.2 DISCUSSION

The study revealed two findings. Firstly, it was found that learning using VCL together with CSCL improved the students 'learning achievement and secondly, that these students were engaged. On the other hand, there was no significant improvement in the students' learning achievement using RL.

5.2.1 Learning Achievement Test

The researcher administered pretest and posttest with 40 multiple choice questions carrying one mark each to both control and experimental groups. To examine the students' chemistry knowledge on the periodic table, a pretest was administered prior to the research. These questions with a very slight difference but with the same level of difficulty were used for posttest at the end of the treatment to both the groups. The finding showed that the significance value (p) in table 4.2 for the control group was 0.982 while the experimental group was 0.001 as indicated in table 4.3. These values indicated that there was significant increase in the scores of the students for the experimental group but a very slightly similar score between the pretest and posttest of the control group. This can be seen from the mean score of pretest were 25.70 and 26.65 for control group and experimental group respectively. While the posttest mean score of experimental group increased to 34.25, that of the control group almost stayed the same at 25.75. It should be noted however that the average test score from both group was beyond average. No students were below average from both groups. It can be argued that students from both groups were at the same level at the start of this research because their pretest mean score was almost identical 25.70 and 26.65 for control and experimental respectively. However the significant increase in mean average score of 34.25 for the experimental group showed that teaching students in VCL together with CSCL improved their learning achievement.

These findings were parallel to the studies carried out by; (Feisel & Rosa, 2005), which showed the effectiveness of the virtual lab in developing the academic achievement of the female students of 2nd secondary grade, in chemistry. (Slater & Usoh, 1993), their project aimed at using virtual labs as a learning environment to support the learning process in the academic achievement of science course intermediate school. The study revealed that using virtual labs encouraged students to modify the wrong concepts and ultimately improved their learning achievement; (Al-Shehri, 2009), in his research, he showed the positive effect of using the virtual labs on providing the student with the laboratory experiment skills and academic achievement in the biology course of 3rd secondary school students, in Jeddah. (Tracey & Bridget, 2007), her study aimed at studying students' onions, at the University of Northern Illinois, U.S.A, concerning the virtual biological labs. It revealed that 86.9% of the students' learning achievement improved.

All their findings showed that there was a significant improvement in the students' learning achievement with the use VCL. These findings prove that leaners perform better when taught with the support of a computer to do experiments than doing them in a traditional way.

The possible reasons to account for high test scores in posttest by the experimental group could be because students were allowed to use a computer and work in groups in this study. Therefore these findings are supported by Dale (1969) learning theory. According to Dale's cone of learning theory, the rates were highest with teamwork. Furthermore the finding of the study, that the use of VCL together with CSCL improved the students' learning achievement, is supported by the theory of constructivism. Students were actively involved in knowledge construction rather than being a passive listener. CSCL encouraged learner's to involve actively, share their ideas and provide feedbacks which helped them construct knowledge on their own while the teacher played the role of facilitator.

5.2.2 Students Observations

Observations results revealed that students were actively engaged during this study. Table 4.6 summarizes the students' non-engagement behavior. Ten students were involved in non-engagement behavior as reflected in Table 4.6. For example, two students looked around for at least two minutes during the experiment. One student made noise two times while another one turned his body and moved out of his seat two times. These are some of the non-engagement behaviors that the students were involved in. It should be noted however that 10 students were not involved in any sort of off-task or non-engagement behavior. Figure 4.4 shows that 20% of time was spent on off-task behavior and 80% of the time was spent on-task which can be concluded that VCL experiments and working together in groups kept the students engaged.

These findings were in line with the studies carried out by; (Palincsar & Brown, 1984), learning by design; this research showed that CSCL emphasized deep engagement with the learning materials as well as collaboration. Hwang, Chen, Shadiev, Huang, and Chen (2014) found that the students in the technology-supported situational learning group wrote more sentences, interacted more, engaged more and developed better writing skills. Teacher education and technology use were also the foci of work by Bell, Maeng, and Binns (2013) whose case study of student teachers in science classrooms showed very high levels student engagement whose academic program stressed inquiry approaches and situated cognition. Interestingly, Bell et al. (2013) attributed this level of engagement, at least in part, to the fact that the students had learned about using technology in teaching in science-specific teaching methodology courses.

It can be argued that the use of technology, working together, interacting and sharing ideas or opinions with fellow peers are all accountable for the high levels of student engagement. Another reason for student engagement could be due to more freedom given to them by the use of technology whereby they can select their own equipment to use in the experiment, choose the materials or chemicals for the experiment and write an e-lab report at the end of the experiment. Also, another reason for student engagement was that they had no fear of making mistakes or breaking glassware or hurting their peers during the experiments, VCL renders safety concerns and this provides students with high confidence that they don’t get in real labs.

These findings are parallel with early scholars in education. For example, in John Dewey's experiential learning theory; he mentions that everything occurs within a social environment. Knowledge is socially constructed and based on experiences. This knowledge should be organized in real-life experiences that provide a context for the information. VCLs are a perfect example of real-life experiences. Take Hudson & Degast-Kennedy (2009) research for example; they demonstrated student engagement in their experiment which involved the creation of a Canadian border simulation. The results of this impressive creation indicated that the students gained real life experience where a real scenario would not be possible, and also developed key interview skills. Their post-class interviews revealed that students were highly engaged and satisfaction in the learning experience was achieved. More importantly, those who actively participated achieved a remarkably high exam grades than those who did not.

Similarly, Dale describes learning through his research that he referred to as the cone of experience. The Cone shows the progression of experiences from the most concrete (at the bottom of the cone) to the most abstract (at the top of the cone). Dale explains that learning is less likely to occur at the top of the cone as opposed to the bottom of the cone where real-life experiences are more involved. Tam (2000) when he explained the role of constructivism he said that it promotes social and communication skills by creating a classroom environment that emphasizes collaboration and exchange of ideas. Students must learn how to articulate their ideas clearly as well as to collaborate on tasks effectively by sharing in group projects. Students must therefore exchange ideas and so must learn to "negotiate" with others and to evaluate their contributions in a socially acceptable manner. This is essential to success in the real world, since they will always be exposed to a variety of experiences in which they will have to cooperate and navigate among the ideas of others.

5.3 RECOMMENDATION

5.3.1Recommendation for Practice

This study revealed that the use of VCL together with CSCL improved the students' learning achievement and also kept the students engaged in learning the periodic table during a chemistry lesson. The ultimate goal of any educator is to improve students learning achievement and see that they are engaged in their lessons. The use of VCL together with CSCL provides this, not just for chemistry but other subjects as well. The following recommendations have been made based on the findings of the study with the hope it can be of great help for chemistry teachers and perhaps other science subjects like physics and biology.

1) The use of VCL together with CSCL should be encouraged during teaching and learning of chemistry in schools since it improved the learning achievement, and kept students engaged during lessons.

2) Other topics in chemistry may also be taught using VCL together with CSCL.

3) This study may provide references for future researchers in the related field.

5.3.2 Recommendation for future research

1) This study was limited to 40 students of 10^{th} grade in two classes. For further study, similar research can be conducted for different grade levels and sample size.

2) Future research may need to be carried out for a longer period of time to give more reliable and significant results.

3) This study involved the use of VCL combined with the use of CSCL other researchers may combine VCL with other learning methods.

4) For more authentic results, the researcher may invite a colleague to observe the students learning unlike in this study where the researcher made the observations.

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APPENDICES

APPENDIX A

LETTER OF RECOMMENDATION TO DO RESEARCH AT A PRIVATE SCHOOL

The Academic Director
Sarasas Witaed Ratchaphruek School
Pak Kret Nonthaburi 11120

Date: 22 June 2017

Subject: Request for Permission to Collect Data at your School

Dear Sir,

The Faculty of Education for the M. Ed. Program in Curriculum and Instruction would like to request your permission for Mr. Nouredine Ssekamaanya (ID: 5906969) a Master's Degree student in the above mentioned programme to collect data for his thesis in the period of 1 June - 31 July 2017. The data obtained will be absolutely confidential and will only serve for educational purposes of Mr. Nouredine's study.

Thank you for your kind consideration.

Truly yours,

Anchalee Chayanuvat

Assistant Professor Anchalee Chayanuvat, Ed.D.
Dean of Faculty of Education
Rangsit University
Muang-Ake. Paholyothin Road
Lakhok, Pathumtani 12000 THAILAND

Tel +662-997-2222 ext. 1275, 1276
Fax +662-997-2222 ext. 1277

APPENDIX B

PRE-TEST

1. The maximum number of electrons that can occupy the third principal energy level is

a. 18.
c. 2.
b. 32.
d. 8.

2. Stable electron configurations are likely to contain

a. high-energy electrons.
b. unfilled s orbitals.
c. fewer electrons than unstable configurations.
d. filled energy sublevels.

3. Which of the following elements is a metalloid?

a. As
c. Br
b. Se
d. Kr

4. The element iodine, I, is a

a. period 5 alkali metal.
c. period 5 halogen.
b. period 4 halogen.
d. period 5 transition metal.

5. The alkali metals do *not* include

a. Li.
c. Na.
b. Ca.
d. Rb.

6. The modern periodic table is arranged in order of increasing

a. atomic mass.
c. atomic size.
b. atomic number.
d. atomic radius.

7. How many valence electrons does an atom of any element in Group 6A have?

a. 2
c. 6
b. 4
d. 8

8. Metals are good conductors of electricity because they

a. form crystal lattices. **b.** contain positive ions.

c. contain mobile valence electrons. **d.** form ionic bonds.

9. Which of the following is *not* a part of Dalton's atomic theory?

a. All elements are composed of atoms. **b.** Atoms of the same element are alike.

c. Atoms are always in motion. **d.** Atoms that combine do so in simple whole-number ratios.

10. The nucleus of an atom is

a. negatively charged and has a low density.

b. negatively charged and has a high density.

c. positively charged and has a low density.

d. positively charged and has a high density.

11. Dalton theorized that atoms are indivisible and that all atoms of an element are identical

scientists now know that

a. Dalton's theories are completely correct.

b. atoms of an element can have different numbers of protons.

c. atoms are all divisible.

d. all atoms of an element are not identical but they all have the same mass.

12. The number of neutrons in the nucleus of an atom can be calculated by

a. adding together the numbers of electrons and protons.

b. subtracting the number of protons from the number of electrons.

c. subtracting the number of protons from the mass number.

d. adding the mass number to the number of protons.

13. The sum of the protons and neutrons in an atom equals the

a. atomic number.

c. atomic mass.

b. number of electrons.

d. mass number.

14**.** All atoms of the same element have the same:

a. number of protons.

c. mass number.

b. number of neutrons.

d. mass.

15**.** Which of these statements is false?

a. Electrons have a negative charge.

b. Electrons have a mass of 1 amu.

c. The nucleus of an atom is positively charged.

d. The neutron is found in the nucleus of an atom.

16**.** An atom of an element with atomic number 48 and mass number 120 contains

a. 48 protons, 48 electrons, and 72 neutrons.

b. 72 protons, 48 electrons, and 48 neutrons.

c. 120 protons, 48 electrons, and 72 neutrons.

d. 72 protons, 72 electrons, and 48 neutrons.

17**.** How do the isotopes hydrogen-2 and hydrogen-3 differ?

a. Hydrogen-3 has one more electron than hydrogen-2.

b. Hydrogen-3 has two neutrons.

c. Hydrogen-2 has three protons.

d. Hydrogen-2 has no protons.

18**.** The number 80 in the name bromine-80 represents

a. the atomic number.

b. the mass number.

c. the sum of protons and electrons.

d. none of the above

19**.** Which of these statements is *not* true?

a. Atoms of the same elements can have different masses.

b. The nucleus of an atom has a positive charge.

c. Atoms of isotopes of an element have different numbers of protons.

d. Atoms are mostly empty space.

20. If the electron configuration of an element is $1s^22s^22p^63s^23p^5$, the element is

a. iron.

b. bromine.

c. chlorine.

d. phosphorus.

21. As the frequency of light increases, the wavelength

a. increases.

b. remains the same.

c. decreases.

d. approaches the speed of light.

22. Stable electron configurations are likely to contain

a. high-energy electrons.

b. unfilled s orbitals.

c. fewer electrons than unstable configurations.

d. filled energy sublevels.

23. Bohr's contribution to the development of atomic structure

a. was referred to as the "plum pudding model."

b. was the discovery that electrons surround a dense nucleus.

c. was proposed that electrons travel in circular orbits around the nucleus.

d. is the quantum mechanical model.

24**.** What is the total number of orbitals in the third principal energy level?

a. 1

b. 4

c. 9

d. 16

25. The frequency and wavelength of all waves are

a. directly related.

b. inversely related.

c. unrelated.

d. equal.

26. The SI unit of cycles per second is called a

a. photon.

b. quantum.

c. hertz.

d. hund.

27. The wavelength of light with a frequency of 2.50×10^{13} s^{-1} is

a. 1.20×10^{5} m.

b. 8.33×10^{5} m.

c. 1.20×10^{-5} m.

d. 8.33×10^{-5} m.

28. Once the electron in a hydrogen atom absorbs a quantum of energy, it

a. is now in its ground state.

b. is now in its excited state.

c. has released a photon.

d. none of the above

29. Elements with valency 1 are

a. always metals

b. either metals or non-metals

c. always metalloids

d. always non-metals

30. An atom with 3 protons and 4 neutrons will have a valency of

a. 3

b. 1

c. 7

d. 4

31. Which of the following in Figure below do not represent Bohr's model of an atom correctly?

a. (i) and (ii)

b. (ii) and (iv)

c. (ii) and (iii)

d. (i) and (iv)

32. Atomic models have been improved over the years. Arrange the following atomic models in the order of their chronological order

(i) Rutherford's atomic model

(ii) Thomson's atomic model

(iii) Bohr's atomic model

a. (i), (ii) and (iii)

b. (ii), (i) and (iii)

c. (ii), (iii) and (i)

d. (iii), (ii) and (i)

33. Which particles are referred to as nucleons (subatomic particles located in the nucleus)?

a. protons and neutrons

b. protons and electrons

c. neutrons, only

d. neutrons and electrons

34. A Ca^{2+} ion differs from a Ca^{0} atom in that the Ca^{2+} ion has

a. more electrons

b. fewer protons

c. more protons

d. fewer electrons

35. What is the mass number of an atom that contains 19 protons, 19 electrons, and 20 neutrons?

a. 39

b. 58

c. 19

d. 20

36. Atoms of ^{16}O, ^{17}O, and ^{18}O have the same number of

a. protons, but a different number of electrons

b. c. protons, but a different number of neutrons

c. electrons, but a different number of protons

d. d. neutrons, but a different number of protons

37. All atoms of an element have the same

a. number of neutrons

b. atomic mass

c. atomic number

d. mass number

38. How many protons are in the nucleus of an atom of beryllium?

a) 2 b) 4 c) 9 d) 5

39. Which subatomic particle is negative?

a) proton b) neutron c) electron d) nucleus

40. What subatomic particle was discovered in the cathode ray tube experiment?

a) proton b) electron c) neutron d) gravitron

APPENDIX C

POST-TEST

1. Stable electron configurations are likely to contain

a. high-energy electrons.

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(iii) Bohr's atomic model

a. (i), (ii) and (iii)

c. (ii), (iii) and (i)

b. (ii), (i) and (iii)

d. (iii), (ii) and (i)

36. Atoms of ^{16}O, ^{17}O, and ^{18}O have the same number of ;

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b. protons, but a different number of neutrons

c. electrons, but a different number of protons

d. neutrons, but a different number of protons

37. All atoms of an element have the same

a. number of neutrons
c. atomic number
b. atomic mass
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38. How many protons are in the nucleus of an atom of beryllium?

a) 2 b) 4 c) 9 d) 5

39. What subatomic particle was discovered in the cathode ray tube experiment?

a) proton b) electron c) neutron d) gravitron

40. Which subatomic particle is negative?

a) proton b) neutron c) electron d) nucleus

APPENDIX D

PRETEST/POSTTEST IOC

Questions	Expert 1	Expert 2	Expert 3	Average	Remarks
Question 1	+1	+1	+1	+1	Congruent
Question 2	+1	+1	0	0.67	Congruent
Question 3	+1	+1	+1	+1	Congruent
Question 4	+1	+1	+1	+1	Congruent
Question 5	+1	+1	+1	+1	Congruent
Question 6	+1	+1	+1	+1	Congruent
Question 7	+1	+1	+1	+1	Congruent
Question 8	+1	+1	0	0.67	Congruent
Question 9	+1	+1	+1	+1	Congruent
Question 10	+1	+1	+1	+1	Congruent
Question 11	+1	+1	+1	+1	Congruent
Question 12	+1	+1	+1	+1	Congruent
Question 13	+1	+1	+1	+1	Congruent
Question 14	+1	+1	+1	+1	Congruent
Question 15	+1	+1	+1	+1	Congruent
Question 16	+1	+1	+1	+1	Congruent
Question 17	+1	+1	+1	+1	Congruent
Question 18	+1	+1	+1	+1	Congruent
Question 19	+1	+1	+1	+1	Congruent
Question 20	+1	+1	+1	+1	Congruent
Question 21	+1	+1	0	0.67	Congruent
Question 22	+1	+1	+1	+1	Congruent
Question 23	+1	+1	+1	+1	Congruent
Question 24	+1	+1	+1	+1	Congruent
Question 25	+1	+1	0	0.67	Congruent
Question 26	+1	+1	0	0.67	Congruent
Question 27	+1	+1	0	0.67	Congruent
Question 28	+1	+1	+1	+1	Congruent
Question 29	+1	+1	+1	+1	Congruent
Question 30	+1	+1	+1	+1	Congruent
Question 31	+1	+1	+1	+1	Congruent

Question 32	+1	+1	+1	+1	Congruent
Question 33	+1	+1	+1	+1	Congruent
Question 34	+1	+1	+1	+1	Congruent
Question 35	+1	+1	+1	+1	Congruent
Question 36	+1	+1	+1	+1	Congruent
Question 37	+1	+1	+1	+1	Congruent
Question 38	+1	+1	+1	+1	Congruent
Question 39	+1	+1	+1	+1	Congruent
Question 40	+1	+1	+1	+1	Congruent
Average of Expert/IOC	**1**	**1**	**0.85**	**0.95**	

APPENDIX E

OBSERVATION STUDENT ENGAGEMENT SHEET

Observation of Student Engagement in a CSCL-VCL class

Observer: _________Date: _______Time start: ___Time end: ____Total time: ___

Student: ___________________________ Class: _______

Class type: ___________________ Class size: ___________ Teacher: __________

Instructional setting: _____________Activity: _____________

Engaged		**Non-Engaged (motor, verbal and passive off-task)**
Active (**AE**)	Passive (**PE**)	
Asking questions(AQ) Talking about learning material(TLM) Talking to peer about learning material(TPLM) Points to computer and explains to peer(PC) Holds and moves computer mouse(HM)	Looking to computer(LC) Reading silently(RS) Listens to teacher(LT) Looking to assigned material(LM)	Out of seat (OS) Touching another student (TS) Turning his body away/ head down fidgeting in seat (TA) Making noise quietly/loudly (MN) Talking at inappropriate times (TT) Looking around room/ turning away(LA)

Based on BOSS terminology

Student A

Time sampling for each student												
Rate of Interval: **15 seconds**												Time(minutes)
												3
												6
												9
												12
												15
												18
												21
												24
												27
												30

Student B

Time sampling for each student												
Rate of Interval: **15 seconds**												Time(minutes)
												3
												6
												9
												12
												15
												18
												21
												24
												27
												30

Any other comments:

(Expert Name/ Sign)

APPENDIX F

OBSERVATION IOC

Observations

Item	Expert Rating				Remarks
	Expert 1	Expert 2	Expert 3	Average	
1	+1	+1	+1	+1	Congruent
2	+1	+1	+1	+1	Congruent
3	+1	+1	+1	+1	Congruent
4	+1	+1	0	0.67	Congruent
5	+1	+1	+1	+1	Congruent
6	+1	+1	+1	+1	Congruent
7	+1	+1	+1	+1	Congruent
8	+1	+1	+1	+1	Congruent
9	+1	+1	+1	+1	Congruent
10	+1	+1	+1	+1	Congruent
11	+1	+1	+1	+1	Congruent
12	+1	+1	+1	+1	Congruent
13	+1	+1	+1	+1	Congruent
14	+1	+1	+1	+1	Congruent
15	+1	+1	+1	+1	Congruent
16	+1	+1	+1	+1	Congruent
17	+1	+1	+1	+1	Congruent
18	+1	+1	0	0.67	Congruent
19	+1	+1	0	0.67	Congruent
20	+1	+1	+1	+1	Congruent
Average of Expert/IOC	**1**	**1**	**0.85**	**0.95**	

APPENDIX G

LESSON PLANS

M4A Lesson Plan

Subject: Chemistry

Topic: The periodic table

Duration 120 minutes (2 lessons)

Learning Objectives:

Students should understand how chemists began to organize the known elements.

Students should understand how Mendeleev organized his periodic table

Students should be able to identify the classes of elements.

Lesson 1: Organizing elements

Purpose: The purpose of this lesson is provide students with an understanding of how elements are organized.

Materials: samples of elements, or photographs of elements, pictures of the modern and ancient periodic table.

Procedure:

- Teacher points out the vocabulary that metal, nonmetal, and metalloids all have the same root and discusses the meaning of the suffix "oid" and prefix "non".
- Teacher will have students study Mendeleev's version of the periodic table in groups of 3 or 4. And point out that they will use mendleev's idea to construct their own periodic table.
- Teacher will direct students' attention to the modern periodic table and then compare it to Mendeleev's periodic table again these discussions are done in groups. individuals in a particular group are expected to interact with each other.
- **Reading strategy** Teacher will write down the following terms on top of the sheet of paper: groups, periods, periodic law, periodic table, repeating properties, metals, nonmetals, and metalloids.
- Teacher will group the students in groups of 3 or 4. They will construct concepts maps relating these terms as they progress through the chapter.

Lesson 2: Constructing the periodic table

Materials:

Before class teacher prepares:

For each group of students, teacher assembles a collection of 20 objects (Five sets of four objects) in a bag. Teacher provides a bag containing 19 of these objects. A collection of objects include sets of coins (penny, nickel, dime, quarter), sets of buttons that are similar but vary in diameter, and washers that vary in diameter. Other objects, such as nuts, bolts, and paper circles.

Each group:

- ✓ bag of objects
- ✓ A computer
- ✓ metric balance

Procedures:

- Teacher will introduce the activity and discuss that we have classification systems for many things in your life.
- Students will write down 5 things that we might classify.
- Within table groups students will agree upon one item and describe the ways it may be classified.
- One group member will write their answers on a piece of paper.
- The teacher may discuss, based on responses, such things as clothes, books, and CDs and emphasize that there are many classification systems in use every day. There are also many classification systems in science, and one of the most important is the Periodic Table of the Elements.

CSCL activity: In this lab you will develop your own classification system for a collection of ordinary objects. You will analyze trends in your system and compare your system with the periodic table of the elements.

1. Groups will receive a bag of objects. Each bag is missing one item.
2. Teacher will instruct the students to examine the items carefully, and identify the missing object. Describe the object in as many ways as you can imagine. Emphasize that they include the reasons why you think the missing object has these characteristics.

3. On their computer screens students will have a table so that a grid of five rows of four squares
4. Arrange your objects on the grid in a logical order.(you must decide what order is logical!) you should end up with one blank square for the missing object.
5. Describe the basis for your arrangement.
6. Measure the mass (g) and the diameter (mm) of each object, and record your results in the appropriate square. Each square (except the empty one) should have one object and two written measurements on it.
7. Examine your pattern again. Does the order in which your objects are arranged still make sense? Explain.
8. Rearrange the squares and their objects if necessary to improve your arrangement. Describe the basis for the new arrangement.
9. Working across the rows, number the squares 1 to 20. When you get to the end of a row, continue numbering in the first square of the next row.
10. Draw conclusions:
    How is your arrangement of objects similar to the periodic table provided?
    How is your arrangement different from that periodic table?
    Look back at your prediction about the missing object.
    Do you think it is still accurate?
    Try to improve your description by estimating the mass and diameter of the missing object. Record your estimates.

Extension: Students will try filling up the empty periodic table in order of increasing atomic mass just as Medleev constructed the first periodic table.

M4A Lesson Plan

Subject: Chemistry

Topic: Atomic structure

Duration 120 minutes (2 lessons)

Lesson 1: Structure of the nuclear atom

Materials: Blank paper, one computer for each group, pictures of x-rays, CT scans

Learning Objectives

- To explain how early scientists described atoms.
- To identify instruments used to observe individual atoms.
- To identify the 3 types of subatomic particles.
- To describe the structure of atoms according to the Rutherford atomic model.

Procedure:

Teacher divides students into groups of 3.

Engage: Teacher asks students to work in groups and think of objects that require experimental data in order to "picture" them, either because they are small or inaccessible.

Critical thinking: Teacher asks students how we could determine what's beneath our skins without dissecting it. (x-rays, CT scans etc) Students will then point out the role of technology in today's life but they should be aware that this technology did not start yesterday but early scientist invented it thus introducing William Crookes' discovery of the negatively charged electrons by the use of a cathode ray tube.

CSCL Activity: Each group of students will use a computer simulation to join particles together.

Students will also observe atomic interactions through this simulation.

Students will find out how many particles of a particular element are required to join with another element to form a new compound.

Students will compare the particles they have put together and their movement in the simulation to Dalton's atomic theory.

Lesson 2: Distinguishing among atoms

Materials: computers, periodic table, pictures of some elements

Learning objectives:

- To explain what makes elements and isotopes different from each other.
- To identify the difference between isotopes of an element.
- To calculate the atomic mass of an element.

Procedure:

Prior Knowledge: Teacher asks one group of students to come forward and review their models and Dalton's atomic theory from the previous lesson. Students will discuss the simulations they made from the previous week. Teacher may ask another group of students to draw an atom and label it with important characteristics such as charge.

Visuals: Teacher will have students look at the periodic table and point out that the atomic number is equal to the number of protons for each element.

Engage: Teacher may ask students why must the number of electrons equal the number of protons for each element. Students may discuss their answer as a group.

CSCL Activity: Each group of students will create an element card using a computer. The card will include the element name, symbol, atomic number, atomic mass, protons, electrons and neutrons.

M4A Lesson Plan

Subject: Chemistry

Topic: Electrons in an atom

Duration: 120 minutes (2 lessons)

Lesson 1: The atomic model

Materials: computer, youtube video, textbook, and worksheet.

Learning objectives:

To describe what Bohr proposed in his model of atom.

To describe what the quantum mechanical model determines about electrons in an atom.

To explain how sublevels of principal energy differ.

Procedure:

Visuals: Teacher show a video of a glowing metal. Teacher explains that Rutherford's model failed to explain why objects change color when heated. As temperature of iron scroll is increased, it first appears black, then yellow, and then white. Teacher explains that this could be possible only if iron gave off light in specific amounts of energy. Teacher concludes that a better atomic model was therefore needed. Hence the introduction of the Bohr model.

Engage: Students witness an example of a quantized energy. Teacher asks a student to blow into a trumpet. Teacher challenges the student to produce as many different notes as he or she can without depressing any valves.

CSCL Activity: Student work in groups to answer given questions by searching information from the internet.

Lesson 2: Quantum Mechanical Model

Materials: computer, whiteboard, and markers

Procedure:

Visuals: Teacher draws or asks student to draw a dartboard on the board with concentric circles of decreasing value. Teacher draws 20 or so small solid dots and explains that the dots represent the dart holes made by two dart players. Teacher makes sure that the dart holes are closer to the bull's eyes than the edge.

In groups students will discuss and then describe the distribution of holes.

Making connection: Teacher will ask how is the distribution of holes analogous to the distribution of electrons in an atom? Again in groups students discuss and find a relationship to this analogy.

CSCL Activity: Students will use their computers to draw shapes of s and p orbitals and their orientation in a 3D system. After drawing students will then explain what type of orbitals do their drawings represent.

M4A Lesson Plan

Subject: Chemistry

Topic: Electron Arrangement

Duration: 120 minutes (2 lessons)

Lesson 1: Atomic emission Spectra

Materials: computer, photographs of electromagnetic spectrum, sealed boxes containing different materials like tennis ball, golf ball etc

Learning objectives:

To list the three rules for writing the electronic configuration of elements.

To explain what causes atomic emission spectra

To distinguish between quantum mechanics and classical mechanics

To explain how the frequencies of emitted light are related to changes in electron energies.

Procedure:

Vocabulary build-up: Teacher explains the vocabulary word "emission" that it comes from the latin word "emittere" meaning to "send out". The word spectrum is latin for "appearance". Teacher then explains that an atomic emission spectrum allows the light sent out from an atom to be seen.

Visuals: Teacher uses a photograph of electromagnetic spectrum to explain wave length, frequency, and radiation.

Activity: Teacher will give students and activity to discover information about objects without seeing them. In this activity students will work together in groups to guess the items in the box.

The teacher will pass the boxes around the classroom and will record the student observations and guesses about what I sinside the black box. Students must come up with ideas to make the best guess of which items are in the box. For example students may think of moving the box and listen to what is inside.

Students will then report which items they found and what procedure or trick they used to make the right guess.

Lesson 2: The Quantum Concept and Photons

Materials: computer, lab materials

Learning objectives:

Students use flame test to determine the identity of the cation in unknown sample or solution.

Procedure:

Chemistry connect: Teacher review's Max Planck's equation of E = h x v and explains that energy could be absorbed or emitted by a body only in quanta given by the equation above.

Teacher also explains that each gas emits light at different wavelength. This wavelength determines the characteristic color of light associated with a particular gas.

CSCL Activity:

In this activity students will use a computer to carry out a flame test lab. Students will make observations and record these observations in an e-lab book.

The procedure for this lab will be given to each group of students and they are expected to work together to complete the activity.

APPENDIX H

IOC LESSON PLANS

Lesson Plan	Expert rating				Remarks
	Expert 1	Expert 2	Expert 3	Average	
1.1	0.67	0.83	0.83	0.77	Congruent
1.2	1	1	1	1	Congruent
2.1	1	1	1	1	Congruent
2.2	1	1	1	1	Congruent
3.1	1	1	1	1	Congruent
3.2	1	1	1	1	Congruent
4.1	0.67	0.83	0.83	0.77	Congruent
4.2	1	1	1	1	Congruent
Average of Expert/IOC	**0.92**	**0.96**	**0.96**	**0.94**	

APPENDIX I

T-TEST RESULTS

```
T-TEST GROUPS=group(2 3)
  /MISSING=ANALYSIS
  /VARIABLES=controlexperimetalpretest
  /CRITERIA=CI(.95).
```

T-Test

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
controlexperimetalpretest	pretestcontrol	20	25.7000	7.51210	1.67976
	pretestexperimental	20	26.6500	7.85577	1.75660

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
controlexperimetalpretest	Equal variances assumed	.005	.946	-.391	38	.698	-.95000	2.43048	-5.87025	3.97025
	Equal variances not assumed			-.391	37.924	.698	-.95000	2.43048	-5.87057	3.97057

```
T-TEST GROUPS=group(4 5)
  /MISSING=ANALYSIS
  /VARIABLES=controlexperimetalposttest
  /CRITERIA=CI(.95).
```

T-Test

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
controlexperimetalposttest	postestcontrol	20	25.7500	6.64019	1.48479
	posttestexperimental	20	34.2500	5.57131	1.24578

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
controlexperimetalposttest	Equal variances assumed	.826	.369	-4.386	38	.000	-8.50000	1.93819	-12.42366	-4.57634
	Equal variances not assumed			-4.386	36.887	.000	-8.50000	1.93819	-12.42755	-4.57245

```
T-TEST GROUPS=group(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=control
  /CRITERIA=CI(.95).
```

T-Test

[DataSet0]

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
control	.00	20	25.7000	7.51210	1.67976
	1.00	20	25.7500	6.64019	1.48479

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
control	Equal variances assumed	.606	.441	-.022	38	.982	-.05000	2.24192	-4.58852	4.48852
	Equal variances not assumed			-.022	37.436	.982	-.05000	2.24192	-4.59077	4.49077

```
T-TEST GROUPS=group(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=experimental
  /CRITERIA=CI(.95).
```

T-Test

[DataSet0]

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
experimental	pretest	20	26.6500	7.85577	1.75660
	post test	20	34.2500	5.57131	1.24578

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
experimental	Equal variances assumed	2.711	.108	-3.539	38	.001	-7.60000	2.15352	-11.95957	-3.24043
	Equal variances not assumed			-3.539	34.254	.001	-7.60000	2.15352	-11.97528	-3.22472

APPENDIX J

STUDENT OBSERVATION RESULTS

Time sampling for Student A

Rate of Interval: **15 seconds**												Time (minutes)
LC	LC	LC	LC	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	TA	LM	LM	12
RS	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	HM	15
PC	HM	HM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
TS	LC	LC	LC	LC	LC	LC	LC	LC	LC	LA	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student B

Rate of Interval: **15 seconds**												Time (minutes)
LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TPLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
AQ	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	LC	15
PC	HM	LM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TS	TA	30

Time sampling for Student C

Rate of Interval: **15 seconds**												Time (minutes)
Listens to teacher				Listens to teacher				Listens to teacher				
LA	LC	LC	LC	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TLM	TLM	LT	PC	PC	9
AQ	AQ	TLM	TLM	RS	TLM	TLM	TLM	TLM	TA	LM	LM	12
RS	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	LT	15
PC	HM	HM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LT	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LA	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	LA	TPLM	30

Time sampling for Student D

Rate of Interval: **15 seconds**												Time (minutes)
LT	LT	LT	LA	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	PC	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TPLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	LC	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
AQ	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	LC	15
PC	HM	LM	HM	AQ	LC	TLM	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LA	TLM	TLM	LC	LC	LC	LC	LC	LT	LC	LM	LT	24
MN	HM	HM	HM	HM	HM	HM	HM	HM	HM	MN	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student E

Rate of Interval: **15 seconds**												Time (minutes)
LC	LC	LC	LC	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TT	TLM	TLM	LM	LM	LM	12
RS	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	HM	15
PC	HM	HM	HM	AQ	LC	AQ	QQ	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
AQ	AQ	LC	LC	LC	TS	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student F

Rate of Interval: **15 seconds**												Time (minutes)
LT	LT	LC	LT	RS	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LT	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TPLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
AQ	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	LC	15
PC	HM	LM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LC	LC	LM	LT	LC	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
AQ	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student G

Rate of Interval: **15 seconds**												Time (minutes)
LC	LC	LC	LC	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
RS	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	HM	15
PC	HM	HM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student H

Rate of Interval: **15 seconds**												Time (minutes)
LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	LC	LC	PC	TPLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
AQ	RS	RS	RS	PC	AQ	TLM	PC	HM	HM	HM	LC	15
PC	HM	LM	AQ	AQ	LC	LC	LC	LT	LT	HM	HM	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	HM	HM	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	TPLM	HM	HM	TPLM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	HM	LT	30

Time sampling for Student I												
Rate of Interval: **15 seconds**												Time (minutes)
LC	LC	LC	LC	RS	LT	LT	LT	LT	LC	LC	LC	3
RS	RS	RS	RS	RS	LC	LC	LT	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
RS	RS	RS	AQ	AQ	AQ	TLM	PC	HM	HM	HM	HM	15
PC	HM	HM	HM	AQ	LC	LC	PC	LT	PC	PC	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student J												
Rate of Interval: **15 seconds**												Time (minutes)
LA	TA	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TPLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	PC	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
AQ	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	LC	15
PC	HM	LM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	TPLM	TPLM	TPLM	TPLM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	PC	PC	HM	MN	30

Time sampling for Student K												
Rate of Interval: **15 seconds**												Time (minutes)
Listens to teacher				Listens to teacher				Listens to teacher				
LC	TA	LC	LC	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	OS	LM	LM	12
RS	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	HM	15
PC	HM	HM	HM	AQ	LC	LC	LC	LT	PC	PC	PC	18
LM	LM	LM	LM	PC	PC	PC	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LM	LM	LM	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	LM	Hm	TPLM	TPLM	TPLM	TPLM	TPLM	TT	TA	TPLM	30

Time sampling for Student L												
Rate of Interval: **15 seconds**												Time (minutes)
Listens to teacher				Listens to teacher				Listens to teacher				
LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TPLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
AQ	RS	RS	RS	RS	AQ	PC	PC	HM	HM	HM	LC	15
PC	HM	LM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TT	MN	TPLM	30

Time sampling for Student M

Rate of Interval: **15 seconds**												Time (minutes)
LC	LC	LC	LC	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LS	LM	LM	12
RS	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	HM	15
PC	HM	HM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student N

Rate of Interval: **15 seconds**												Time (minutes)
LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TPLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
AQ	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	LC	15
PC	HM	LM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student O

Rate of Interval: **15 seconds**												Time (minutes)
LC	LT	LC	LC	LT	LT	LT	LT	LT	LT	LC	LC	3
RS	LT	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	LT	TPLM	PC	PC	TPLM	TPLM	TLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	PC	LM	LM	12
RS	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	HM	15
PC	HM	HM	HM	AQ	LC	LC	LC	LT	PC	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	HM	HM	30

Time sampling for Student P

Rate of Interval: **15 seconds**												Time (minutes)
LT	LT	LT	LT	LT	LT	LT	LT	LC	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	PC	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TPLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
AQ	AQ	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	LC	15
PC	HM	LM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	HM	HM	30

Time sampling for Student Q												
Rate of Interval: **15 seconds**												Time (minutes)
LC	LC	LC	LC	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	PC	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TLM	LT	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	PC	LM	LM	12
RS	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	HM	15
PC	HM	HM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student R												
Rate of Interval: **15 seconds**												Time (minutes)
LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TPLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	LM	LM	LM	12
AQ	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	LC	15
PC	HM	LM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	LM	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student S												
Rate of Interval: **15 seconds**												Time (minutes)
Listens to teacher				Listens to teacher				Listens to teacher				
LC	LC	LC	LC	LT	AQ	LT	LT	LT	LT	LT	AQ	3
RS	RS	RS	RS	RS	LC	LC	TLM	TLM	LT	LT	LT	6
AQ	TLM	TPLM	PC	PC	TPLM	TPLM	TLM	TLM	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	TLM	PC	LM	LM	12
RS	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	HM	15
PC	HM	HM	HM	AQ	LC	LC	LC	LT	AQ	LT	LT	18
LM	LM	LM	LM	TT	TS	LM	LM	PC	PC	PC	PC	21
LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	LC	LC	AQ	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

Time sampling for Student T												
Rate of Interval: **15 seconds**												Time (minutes)
Listens to teacher				Listens to teacher				Listens to teacher				
LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	3
RS	RS	RS	RS	RS	LC	LC	LC	LT	LT	LT	LT	6
AQ	LM	TPLM	PC	PC	TPLM	TPLM	TPLM	LC	PC	PC	PC	9
AQ	AQ	TLM	TLM	PC	TLM	TLM	TLM	LC	LM	LM	LM	12
AQ	RS	RS	RS	RS	AQ	TLM	PC	HM	HM	HM	LC	15
PC	HM	LM	HM	AQ	LC	LC	LC	LT	LT	LT	LT	18
LM	LM	LM	LM	TS	TT	HM	HM	LM	LM	LM	LM	21
LC	AQ	LC	LC	LC	LC	LC	LC	LC	LC	LC	LC	24
HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	HM	27
AQ	AQ	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	TPLM	30

APPENDIX K

RELIABILITY TEST SCORE

```
GET
GET
  FILE='D:\Thesis work\ioc results\pretest.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
RELIABILITY
  /VARIABLES=Anonymous Experimental
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE CORR
  /SUMMARY=MEANS VARIANCE CORR.
```

Reliability

Notes

Output Created		26-SEP-2017 14:07:04
Comments		
Input	Data	D:\Thesis work\ioc results\pretest.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	
	N of Rows in Working Data File	20
	Matrix Input	
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=Anonymous Experimental /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE SCALE CORR /SUMMARY=MEANS VARIANCE CORR.
Resources	Processor Time	00:00:00.00
	Elapsed Time	00:00:00.07

```
[DataSet1] D:\Thesis work\ioc results\pretest.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	20	100.0
	Excluded[a]	0	.0
	Total	20	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.973	.983	2

Item Statistics

	Mean	Std. Deviation	N
Anonymous	25.1500	6.40127	20
Experimental	26.6500	7.85577	20

Inter-Item Correlation Matrix

	Anonymous	Experimental
Anonymous	1.000	.967
Experimental	.967	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	25.900	25.150	26.650	1.500	1.060	1.125	2
Item Variances	51.345	40.976	61.713	20.737	1.506	215.008	2
Inter-Item Correlations	.967	.967	.967	.000	1.000	.000	2

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
51.8000	199.958	14.14065	2

```
DATASET ACTIVATE DataSet1.

SAVE OUTFILE='D:\Thesis work\ioc results\pretest.sav'
  /COMPRESSED.
```

APPENDIX L

EXPERTS WHO VALIDATED THE INSTRUMENTS

Experts who Validated the Instruments

SL.NO.	Name	Position	Isititution
1	Dr.Donrutai Boonprasitt,	Associate Dean for Administration	Rangsit University, Thailand
2	Mr.Daniel Jagger	Former Head of Science Department and Physics teacher	Satit Bilingual School of Rangsit University, Thailand
3	Mr. George Walugembe	Chemistry teacher	Sarasas Wiated School, Thailand

APPENDIX M

CONSENT FORM

Information Letter and Consent Form for Parents or Guardians

Permission for Research with Children

Date 19/06/2017

Dear **Parent(s) or Guardian(s)**:

I am writing to ask your permission for your child to participate in a Rangsit University educational research on ***The Use of Virtual Chemistry Labs to enhance Students' Learning Achievement and Engagement in Chemistry.*** This research will be conducted at **Satit Bilingual School of Rangsit University** over the next several weeks. We are interested in solving student's learning difficulties in chemistry and helping them engage more in this subject which seems to be difficult for many of them. Students will be using computers to carry out chemistry experiments in a virtual environment. They will also be working in groups.

The research in which your child has been invited to participate is expected to be an enjoyable experience and will not require time out of class. The decision about participation is yours. To help you in this decision, a brief description of the project is provided. At the beginning of this research children will take a pre-test to check their level of understanding the periodic table. Then, research will begin where children work in groups to help each other run virtual chemistry experiments. At the end of this research children will take a post-test to check if they have improved on their knowledge of the periodic table. Also the researcher will be making observations during the lessons to see if students are participating, working and helping each other to do experiments.

All children's performances are considered confidential and individual children's results will not be shared with school staff. However, information based on the results of the group of participants will be provided. Only children in Grade **10** who have parental permission, and who themselves agree to participate, will be involved in the study. Also, children or parents may withdraw their permission at any time during the study without penalty by indicating this decision to the researcher. There are no known or anticipated risks to participation in this study.

I would like to assure you that this study has been reviewed and approved by the Research Ethics Review Board at Rangsit University. In addition, it has the support of the principal at your child's school. However, the final decision about the participation is yours. Should you have any concerns or comments resulting from your child's participation in this study, please contact **Dr. Naipaporn Chalermnirundorn the research supervisor of this particular study at her email: x-huijia@hotmail.com**

We would appreciate it if you would permit your child to participate in this research, as we believe it will contribute to furthering our knowledge of **children's chemistry learning achievement and engagement of the periodic table.** Please complete the attached permission form, whether or not you give permission for your child to participate, and return it to the school by **23rd June 2017.**

If you have any questions about the study, or if you would like additional information to assist you in reaching a decision, please feel free to contact me **Nouredine Ssekamaanya** at **nouredinet@gmail.com** **0894776342** or my faculty supervisor, Dr. **Nipaporn Charlemnirundorn** at, **x-huijia@hotmail.com.** Thank you in advance for your interest and support of this project.

Sincerely,

……………………………..	……………………………
Nouredine Ssekamaanya	Dr. Nipaporn Charlemnirundorn
Student of M.Ed Curriculum & Instruction	Faculty advisor
Rangsit University	Rangsit University

Consent Form – Child

I have read the information letter concerning the research study entitled ***The Use of Virtual Chemistry Labs to enhance Students' Learning Achievement and Engagement in Chemistry*** conducted by **Mr.Nouredine Ssekamaanya** of the Faculty of **Education** at Rangsit University. I have had the opportunity to ask questions and receive any additional details I wanted about the study.

I acknowledge that all information gathered on this project will be used for research purposes only and will be considered confidential. I am aware that permission may be withdrawn at any time without penalty by advising the researchers.

I realize that this project has been reviewed by and approved by the Research Ethics Review Board at Rangsit University, and that I may contact this office if I have any comments or concerns about my son or daughter's involvement in the study.

If I have any questions about the study I can feel free to call the researcher Mr.**Nouredine Ssekamaanya** at **nouredinet@gmail.com 0894776342**

☐ Yes – I would like my child to participate in this study

☐ No – I would not like my child to participate in this study.

Child's Name ____

Child's Birth Date _______________ Gender of Child ____ Male ____ Female

Parent or Guardian Signature ______________________ Date ____________

Researcher's Signature _________________________ Date ____________

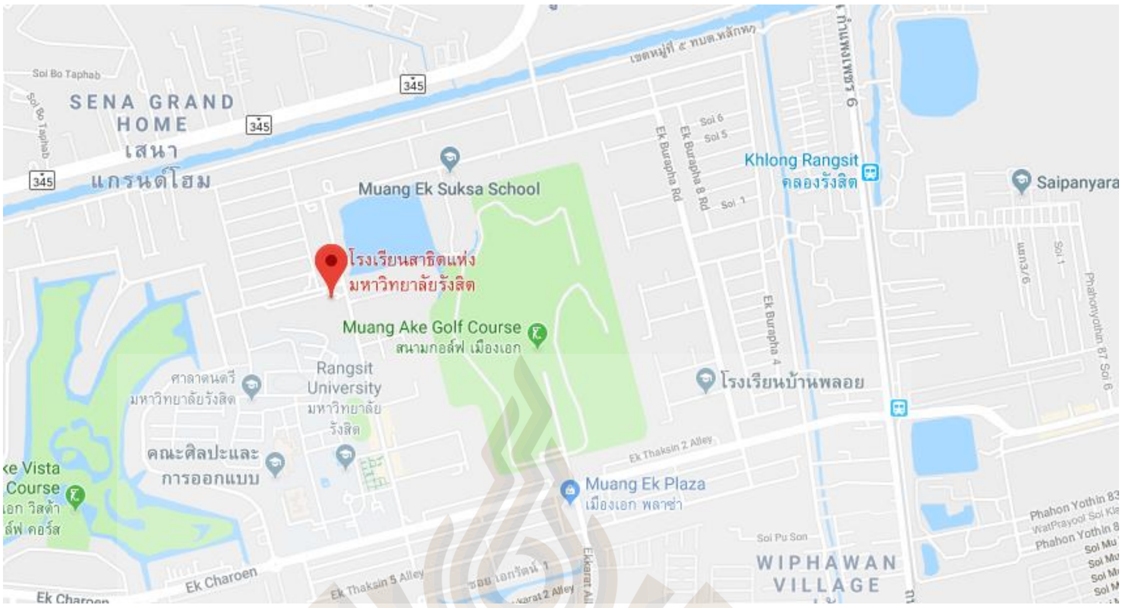
Researcher's Title _________________ Department ___________________

Faculty Advisor Signature _______________________ Date ___________

Faculty Advisor Title _________________Department__________________

APPENDIX N

LOCATION OF RESEARCH SCHOOL


SENA GRAND
HOME
เสนา
แกรนด์โฮม
345
Muang Ek Suksa School
โรงเรียนสาธิตแห่ง
มหาวิทยาลัยรังสิต
Muang Ake Golf Course
สนามกอล์ฟ เมืองเอก
Rangsit
University
มหาวิทยาลัย
รังสิต
ศาลาดนตรี
มหาวิทยาลัยรังสิต
คณะศิลปะและ
การออกแบบ
Khlong Rangsit
คลองรังสิต
Saipanyara
โรงเรียนบ้านพลอย
Muang Ek Plaza
เมืองเอก พลาซ่า
WIPHAWAN
VILLAGE
Ek Charoen
Ek Thaksin 2 Alley
Ek Burapha Rd
Ek Burapha 4

APPENDIX O

STUDENT OBSERVATION CODING INTERPRETATION

AE: Active engaged behavior

PE: Passive engaged behavior

LC: Looking at computer

LT: Listens to teacher

AQ: Asks questions

RS: Reads silently

TPLM: Talks to peer about learning material

PC: Points to computer and explains to peer

TLM: Talks about learning material

HM: Holds and moves computer mouse

LM: Looking at assigned material

NE: Non-engaged behavior

OS: Out of seat

TS: Touching another student

TA: Turning his body away/ head down fidgeting in a seat

MN: Making noise quietly/loudly

TT: Talking at inappropriate times

LA: Looking around room/turning away

BIOGRAPHY

Name	Nouredine Ssekamaanya
Date of Birth	February 12, 1985
Institutions Attended	Makerere University, Kampala Uganda
	Bachelor of Science Industrial Chemistry, 2009
	St.Roberts University, Philippines
	Diploma in Education, 2014
	Rangsit University, Thailand
	Master of Education in Curriculum and Instruction, 2018
Address	52/347 Muang Ake, Phahayothin Road, Lahok, Phathum thani
Position and Office	HOD Science Department
	Chemistry Teacher
	Cambridge Examinations Officer
	Satit Bilingual School Rangsit University