The Integration of Constructivist and Sociocultural Learning Principles with ICT in Teaching Physics

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Abstract

To fulfil the requirement of nation development and globalisation, Vietnam's Ministry of Education and Training (MOET) has introduced educational reforms at primary, secondary and tertiary levels that require Vietnamese teachers to acquire new understanding and skills in using information communication technology (ICT) to support teaching with a student-centred approach. There is, however, little literature to guide Vietnamese teachers on how to achieve these goals.

This thesis aimed at developing, trialling and evaluation a theoretical pedagogic model for integrating student-centred learning principles with ICT for the teaching physics in the Vietnamese context. The project began with the development of an initial theoretical model based on a review of the relevant literature. This model was evaluated by New Zealand and Vietnamese experts and subsequently revised to form the CSI model (The Pedagogic Model of Integrating **C**onstructivist and **S**ociocultural Learning Principles with **I**CT) used in the implementation phase of the project.

The CSI Model was implemented by a lecturer in a university optics course and data was collected from different groups of people (students, observers, the lecturer and a teaching assistant) and by different methods (observations, optics tests, California Critical Thinking Skills Tests, interviews and surveys) to triangulate and enrich the data.

The optics course was taught to two groups. The ICT implementation into optics teaching and learning in both groups was underpinned by the CSI Model. Students

of one group (Morning Group) utilised more ICT applications than the other group (Afternoon Group): the Morning Group students' learning was supported by a learning management system (LMS).

The optics test results show that in both groups, the students' scores in the post-test were statistically significantly higher than their scores in the pre-test. In addition, in the post-test, the group of students who utilised more applications of ICT to support their learning scored significantly higher than the other group. It is noted that there is no statistically significant difference in the pre-test scores of the two groups. Findings from student, lecturer and teaching assistant interviews revealed that most students in the two research groups felt that the way the optics course was taught enhanced their learning and made learning optics fun and exciting.

Results from the California Critical Thinking Skills Tests also showed that post-test scores of the students in both research groups were significantly higher than their pre-test scores. In the post-test, the students scored significantly higher in both the total score as well as the individual scores for each critical thinking skill.

In the research context, the CSI Model appears to be an effective pedagogic model. Findings showed that the model helped to improve the students' physics test scores, enhanced their critical thinking skills, and increased interaction within the learning environment.

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Dedication

To my beloved brother

To my parents, Nguyen Van Dong and Le Thi Thanh Hoa,

for their unconditional love and sacrifices

Publications Arising from this Thesis

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Chapter 1 Introduction

As plants grow from their roots under specific conditions of water, humidity, light, temperature and so on, this thesis will begin with the root of the research idea and the context in which the research was conducted. The chapter consists of six sections. The first section will narrate a story from about nine years ago, that explains the origins of this research idea. Then, some key features of the history and culture of Vietnam's education system will be presented. The third and fourth sections will address issues currently affecting education in Vietnam, which leads to the rationale for the research, the research goal and the research questions. The chapter will end with an overview of the thesis chapters.

1.1 About the Researcher and the Root of the Research Idea

The researcher who conducted this thesis project was a lecturer of a university in Vietnam. She started her career in teaching Physics and Methodology of Teaching at the same university in 2003. This university is a renowned university in the Mekong Delta of Vietnam. The researcher and a head of the School of Education of the university began to write a paper on using MS PowerPoint in teaching in pedagogic ways in 2005. In line with the paper, a group of leading science educators from the School of Education started to develop courses for pre-service and in-service teachers on how to use MS PowerPoint particularly and ICT in general in teaching.

During this time, Vietnam's Ministry of Education & Training (MOET) funded this group and set the mission for the group which was training in-service teachers to use ICT pedagogically. The researcher was a team member of the group. The group trained pre-service secondary teachers as well as university and school in-service teachers in the Mekong Delta by providing them short-term and long-term training courses. The content of the courses was based on recognized good practices and teaching strategies, but did not have a systematic pedagogic framework for integrating ICT in teaching (Le & Nguyen, 2009). There was a strong need for a pedagogic framework which integrates appropriate learning theories with ICT emerges from this teaching practice.

During those years of developing the courses and training in-service and pre-service teachers (2006-2009), *constructivism* also gradually became promoted by the university's School of Education. Some lecturers started to consider constructivism as a theory to underpin their teaching practices. Attracted by the new constructivist breeze and influenced by the current task of training teachers to use ICT pedagogically, the researcher started to consider developing a pedagogic model which integrates constructivist learning principles with ICT in teaching Physics in Vietnam.

1.2 A Hint of Vietnam's Education History and Culture

Vietnam is a small country located in the South East of Asia. Like many countries in Asia (e.g. China, Japan, Singapore, South Korea, Taiwan and Hong Kong), Vietnam is strongly influenced by Confucian philosophy (Tan & Tambyah, 2011; Woodside, 1998). In addition, Vietnam has experienced several historical changes. As a result, the history and culture of Vietnam's education system reflects these features.

1.2.1 Confucian Philosophy and Education in Vietnam

Confucian philosophy has considerably influenced the society of many Asian countries, including Vietnam (V. Q. Hoang & Dung, 2009; Tan & Tambyah, 2011). As a result, education in Vietnam possesses the following characteristics.

The first characteristic is that from the Confucian perspective, teachers hold superior social positions (Pham, 2008). Vietnamese teachers are socially highly regarded and considered to provide students with academic truth (P. M. Nguyen, Terlouw, & Pilot, 2006). It is enforced by Vietnam's Education Law that teachers must continuously train themselves in order to be good role-models for students ("Luật Giáo dục [Education law] (Vietnam)," 2005). Vietnamese students generally pay great respect to their teachers (Ellis, 1994). For example, the students stand up on the teachers' arrival (P. M. Nguyen et al., 2006), speak in classes only when the teachers permit them to speak (Ellis, 1994; P. M. Nguyen et al., 2006), and do not usually contradict or challenge their teachers' ideas (Ellis, 1994; C. Nguyen, 2012). Under the Confucian influence, Vietnamese teachers are generally considered as knowledge deliverers who transfer absolutely accurate knowledge to students (P. M. Nguyen et al., 2006; Pham, 2008).

Secondly, saving face and doing the same for others is very important for Confucian believers (Ellis, 1994; P. M. Nguyen, Terlouw, & Pilot, 2005). As a result of this outlook, Vietnamese students are afraid to discuss or present their ideas because they are afraid of the risks of revealing their problems or making mistakes, and so losing face. Furthermore, these students believe that it is their duty to preserve the reputation of their teachers and classmates (Ellis, 1994). When presenting their arguments, ideas and opinions, the students feel that they may risk humiliating their teachers and their peers (Ellis, 1994). Therefore, Vietnamese students try to avoid presenting their own ideas and discussing in classes (P. M. Nguyen et al., 2005).

Thirdly, it is argued that Vietnamese students' learning approach is surface learning (C. Nguyen, 2012; P. M. Nguyen et al., 2006). For many decades, the examination systems in Confucian influenced countries have required students to remember huge volumes of information and reproduce it on the exam papers (P. M. Nguyen et al., 2006). Teachers are supposed to transmit information to students, and the students, in turn, accumulate and remember the information (C. Nguyen, 2012). This way of teaching and assessing does not require the students to think deeply about what they learn and discover new knowledge. Thus, they tend to adopt surface learning.

According to Pham (2008), under Confucian influence, interactive and cooperative learning and teaching styles are not appropriate for Vietnamese contexts because they "are in serious conflict with traditional perceptions of Vietnamese teachers regarding the nature of teaching and learning" (Pham, 2008, p. 3). If the current study pursues an interactive learning style, the influence of Confucian on Vietnamese culture will be a significant challenge of introducing and making this learning style worthwhile for learning and teaching practice.

1.2.2 Vietnam's Education Reform

Vietnam declared as an independent country in 1945. Since then, Vietnam's education system has experienced several reforms (Mac, 2013). The first reform started in 1950 (C. T. Nguyen, 2012). At that time, the whole country was still at a war. Therefore, the objective of the education reform was to train citizens who were loyal to the nation and able to do service for their people and the war (Mac, 2013). From 1951 to 1999, three more reforms occurred in order to serve the purposes of politics, social and economic development of the nation (Mac, 2013; C. T. Nguyen, 2012).

The most recent reforms occurred in 2000 and 2005. The reform started in 2005 is aimed to complete in 2020. This reform applies to tertiary level while the reform in 2000 focusses on general education (i.e. primary and secondary education). Through the reforms, education and training are considered as a top priority in Vietnam. Vietnam Education Law confirms that education is the foremost National Policy ("Luật Giáo dục [Education law] (Vietnam)," 1998; "Luật Giáo dục [Education law] (Vietnam)," 2005).

The general education reform was instructed by Resolution No. 40 and Instruction No. 14 ("Chỉ thị số 14/2001/CT-TTg về đổi mới chương trình giáo dục phổ thông thực hiện nghị quyết số 40/2000/QH10 của quốc hội [Directive no. 14/2001/CT-TTg on secondary educational program reform for the application of the resolution no. 40/2000/QH10 of the national assembly] (Vietnam)," 2001; "Nghị quyết của quốc hội nước Cộng Hòa Xã hội chủ nghĩa Vệt Nam số 40/2000/QH10 ngày 09 tháng 12 năm 2000 về đổi mới chương trình giáo dục phổ thông [The resolution of The Socialist Republic of Vietnam National Assembly no. 40/2000/QH10 December 09th, 2000 on secondary educational programme reform] (Vietnam)," 2000). The National Assembly of Vietnam also issued the Education Law 1998 as a legitimate foundation for this reform ("Luật Giáo dục [Education law] (Vietnam)," 1998). The objectives of the reform instructed by Resolution No. 40 and Instruction No. 14 are:

- to improve the quality of comprehensive education,

- to innovate teaching and learning methods, to promote creative thinking and self-learning capabilities of students,
- to reach the level of general education of the countries in the region and the world, and
- to create favourable conditions for the organization following ramification at secondary level.

1.3 The Current State of Vietnam's Education System

1.3.1 General Information about the Education System

The Vietnamese education system contains five levels: early childhood, primary, lower secondary, upper secondary and higher education. Children begin their compulsory education (Grade 1) at the age of approximately six. Primary and secondary education includes 12 grades. After finishing upper secondary education (grade 12), students will take the Secondary Graduation Exam; if they pass the exam, they will be granted the Secondary School Graduation Degree. To enter universities and colleges, students must also sit the University Entrance Exam. The majority of college and university majors require students to be tested on at least one natural science subject (biology/ chemistry/ physics) (Vietnam's Ministry of Education and Training, 2011b). This is an important reason for Vietnamese students to learn science.

Overall, there are three main features of Vietnamese education that should be acknowledged. The first feature is that Vietnam education has become more accessible to the general population in recent years. The percentage of the pupils enrolling to primary education is high (around 100%) (Table 1.1). This is a positive sign for Vietnam's literacy. The enrolment ratios of primary education are above 100% in Year 2000, 2010 and 2012 (UNESCO Institute for Statistics, 2014). It is because primary schools do not only attract pupils at the right ages but also older pupils who do not get opportunities to attend primary schools at the right ages. The percentage of students' enrolment in secondary and tertiary education in general increases over the years (Table 1.1). According to Sato (2007), the percentage of students' enrolment in secondary and tertiary education in 1990 was quite low (about 32% for secondary education and about 1.9% for tertiary education). In 2012, these figures are 92% for secondary education and 25% for tertiary education (UNESCO Institute for Statistics, 2014). Table 1.2 presents the enrolment ratios in Vietnam and the developing countries in 2012. While the enrolment ratios of primary and tertiary education in Vietnam are rather similar to those of the developing countries, the enrolment ratio of lower-secondary ratio in Vietnam is 10% higher than the ratio of the developing countries.

Table 1.1 *Gross Enrolment Ratio in Vietnam*

Year	2000	2005	2010	2012
Primary	107%	97%	105%	105%
Lower -Secondary	80%	89%	88%	92%
Tertiary	9%	16%	22%	25%

(UNESCO Institute for Statistics, 2014)

The second feature is that the percentage of female students is nearly equal to the percentage of male students. Table 1.3 presents the percentages of Vietnamese female students at primary, lower-secondary and tertiary levels (UNESCO Institute for Statistics, 2014). The most recent figures in 2011 show that the percentage of the female students is nearly 50%.

Table 1.2 *Gross Enrolment Ratio Year 2012 in Vietnam and the Developing Countries*

	Developing Countries	Vietnam
Primary	110%	105%
Lower -Secondary	82%	92%
Tertiary	26%	25%

(UNESCO Institute for Statistics, 2014)

Table 1.3 *The Percentage Female Students in Vietnam*

	2009	2010	2011
Primary	48%	47%	47%
Lower -Secondary	49%	50%	48%
Tertiary	49%	49%	49%

(UNESCO Institute for Statistics, 2014)

The third feature is that Vietnam is behind Asian-Pacific countries generally and South East Asian countries particularly in tertiary education (T. Hoang, 2007; Saich et al., 2008; Vallely & Wilkinson, 2008). Vietnam has no universities in the top 100 universities of Asia, while other neighbours such as Thailand, Singapore, Malaysia, Indonesia, and Philippines usually are in the list (Times Higher Education, 2011). Researching is not the strength of Vietnamese universities. The number of publications in peer-reviewed journals is not high. For example, in 2007, this number for Vietnam National Universities (Hanoi and Ho Chi Minh City) was 52; and for the Vietnam Academy of Science and Technology, 44 (Vallely & Wilkinson, 2008). These numbers are about a quarter of the publications from the University of the Philippines. The number of patents is also low, for example, zero in 2006 (Vallely & Wilkinson, 2008).

In general, Vietnam has a complete education system for early childhood to tertiary levels. Primary and secondary levels are highly accessible. Females appear to have equal opportunities for education at these levels. Tertiary level is not easy to access for students; its enrolment rate is considerably lower than the enrolment rate of secondary level.

1.3.2 Primary and Secondary Levels

In Vietnam, natural sciences are taught as one subject at the primary level from grade 4, then as different subjects such as biology, chemistry and physics at secondary levels. One reason that the subjects are introduced at the earlier stage is to stretch the time for studying the subjects and thus to spread the study load over a longer period of time.

At upper secondary education, the natural sciences curricula are divided into two levels: basic and advanced. The basic curricula provide fundamental knowledge and skills while the advanced curricula offer more complicated science knowledge and skills. Besides tests and normal exams at each grade, students' knowledge and skills in sciences are assessed by the Secondary Graduation National Examination.

The examination system has a significant impact on the teaching and learning of science. Vietnam has two national examinations to evaluate students' knowledge and skills in the sciences: the Secondary Graduation Exam which determines whether examinees can get the Secondary Degree and sit the University Entrance Exam, and the University Entrance Exam which determines the prestige of the university the examinee will be able to attend. Besides these, there are several other critical examinations such as the Lower-Secondary Graduation Exam which governs progress to upper secondary schooling, and the Upper-Secondary

Entrance Exam which determines the type of upper secondary school a student will attend. The teaching and learning of science in the years when examinations occur are largely dictated by the requirements and content of these examinations.

Vietnam's Education Law, Article 14 states that:

> The government uniformly manages national education system including goals, programs, content, educational planning, teacher standards, examination regulations, the system of diplomas and certificates; focuses on managing educational quality, implementation of the assignment and decentralization of education, and strengthening the autonomy and responsibility of educational institutions ("Luật Giáo dục [Education law] (Vietnam)," 2005, p. 5).

The Vietnam education system is centralised; the government manages the education system by controlling budgets, curricula, content and human resources ("Luật Giáo dục [Education law] (Vietnam)," 2005; Vallely & Wilkinson, 2008).

At the secondary education level**,** a set of science textbooks is compulsorily applied to the whole nation; the Minister of Education and Training issues general education programs and approves the textbooks for official use ("Luật Giáo dục [Education law] (Vietnam)," 2005). MOET invites leading experts in science and education to design the national science textbooks. Applying a set of science textbooks for the whole country has both advantages and disadvantages. An advantage is that MOET centrally invests money and human resources (leading scientists and educators) on a set of science textbooks; as a result, the quality of the textbooks should be high. In a developing country like Vietnam, the budget and the number of highly competent educators appear limited. Therefore, using only one set of national science textbooks sounds reasonable for Vietnam. Conversely, there are disadvantages such as the science textbooks cannot be suitable for all socio-cultural contexts of all different regions. More than 50% of provinces' Departments of Education and Training reported that the current textbooks have not taken the regional context into account (Vietnam's Ministry of Education and Training, 2008).

The MOET conducted a survey to collect feedback from educators in the whole country about the new textbooks in 2008. About 20,000 schools (50% of schools), education and training departments of 60 provinces (94% of total number of the departments), other organisations and educators gave their feedback. The result of the survey shows that the current science textbooks have three main strong points (Vietnam's Ministry of Education and Training, 2008): (a) The science content is accurate and relatively up to date with the development of science and technology, (b) The content is arranged systematically and logically, and (c) it suits the professional competencies of current teachers. The findings of the survey also point out the limitations of the science content: some of the biology and physics content at upper secondary level is more theoretical than practical, many scientific terms are not consistent, and the physics content at upper secondary education at the basic level is more difficult than the content of the advanced level.

1.3.3 Tertiary Level

Vietnamese tertiary institutions have more autonomy than primary and secondary schools; however, the MOET still controls tertiary curriculum frameworks, enrolment quotas and budget (Hayden & Lam, 2010). The MOET issues curriculum frameworks for the Vietnamese tertiary programmes. These curriculum frameworks comprise the programmes' objectives and structures, number of credits, compulsory courses, the outline of the knowledge, time for theory, practice and internship (Vietnam's Ministry of Education and Training, 2011a). Vietnamese universities and colleges need to comply with the curriculum frameworks when they design and provide their educational programmes. In addition, the grants and enrolment quotas of the universities and colleges are allocated annually by the MOET. By controlling the enrolment quotas, the MOET controls the number of students enrolling in universities and the universities' income from tuition fees. Vietnamese tertiary education is centrally controlled by the MOET in both curriculum and finance (Hayden & Lam, 2010).

The tertiary education reform which began in 2005 is marked by the Resolution No. 14/2005/NQ-CP on Fundamental and Comprehensive Higher Education Reform in Vietnam for the Period of 2006 – 2020. The general goals of this reform are ("Nghị quyết 14/2005/NQ-CP về đổi mới cơ bản và toàn diện giáo dục đại học Việt Nam giai đoạn 2006 - 2020 [The resolution no. 14/2005/NQ-CP on fundermental and comprehensive higher education reform in Vietnam for the period of 2006 – 2020] (Vietnam)," 2005):

- to complete network of establishments of higher education on a national scale,
- to develop higher education programs in the light of research-career oriented,
- to expand the training scale (reaching the rate of 450 students per one thousand people by 2020),
- to develop professional capacities for lecturers and administrators of higher education,

- to make rapid raises in the scale and performance of science and technology in institutions of higher education, and
- to complete policy development for higher education.

One of the resolutions to meet these goals is to use information communication technology in teaching and learning ("Nghị quyết 14/2005/NQ-CP về đổi mới cơ bản và toàn diện giáo dục đại học Việt Nam giai đoạn 2006 - 2020 [The resolution no. 14/2005/NQ-CP on fundermental and comprehensive higher education reform in Vietnam for the period of 2006 – 2020] (Vietnam)," 2005).

Table 1.4 *Teacher-centred Versus Student-centred Approaches*

	Learning	Teaching
Teacher–centred approach	No individual accountability Responsible only for self Passive receive information from teachers	Follow the course profile Try to keep students in their own seats Provide detailed instruction
Student-centred approach	Individual accountability Responsible for each other Actively involved in one’s own learning and in learning processes of peers	Select and divide the lesson for group work Arrange the classroom and assign roles Facilitate learning

(Pham, 2010, p. 30)

Under the influence of the reform, lecturers are encouraged to implement ICT into their teaching (Harman & Nguyen, 2010). A student-centred approach is introduced into classes (Pham, 2010). To clarify the notion of the student-centered and teacher-centered approaches, Pham (2010) identifies the characteristics of these two approaches, presented in Table 1.4.

1.4 Vietnam's Education: Current Issues to be Addressed

1.4.1 Teacher-centred Approach with Low Interaction

Vietnam's government is driving the reform in education and an important goal is to promote innovative teaching and learning methods ("Nghị quyết của quốc hội nước Cộng Hòa Xã hội chủ nghĩa Việt Nam số 40/2000/QH10 ngày 09 tháng 12 năm 2000 về đổi mới chương trình giáo dục phổ thông [The resolution of The Socialist Republic of Vietnam National Assembly no. 40/2000/QH10 December 09th, 2000 on secondary educational programme reform] (Vietnam)," 2000). The teaching approach has been aimed to change from teacher-centred to student-centred ("Nghị quyết 14/2005/NQ-CP về đổi mới cơ bản và toàn diện giáo dục đại học Việt Nam giai đoạn 2006 - 2020 [The resolution no. 14/2005/NQ-CP on fundermental and comprehensive higher education reform in Vietnam for the period of 2006 – 2020] (Vietnam)," 2005). Information communication technologies are promoted to be integrated in education ("Nghị quyết 14/2005/NQ-CP về đổi mới cơ bản và toàn diện giáo dục đại học Việt Nam giai đoạn 2006 - 2020 [The resolution no. 14/2005/NQ-CP on fundermental and comprehensive higher education reform in Vietnam for the period of 2006 – 2020] (Vietnam)," 2005). After about one and a half decades of innovation, the teaching and learning approach in Vietnam is still rather teacher-centred (Pham, 2010; Stephen, Doughty, Gray, Hopcroft, & Silvera, 2006).

At primary and secondary level, Vietnam's MOET (2008) affirms that education programmes have been designed to support innovation in teaching and learning methods; the national textbooks promote learning tasks which support teachers to use new teaching methods and foster students' learning. Although the teaching approach is moving to learner-centred, studies show that teaching methods in science education in Vietnam from primary to secondary education seem to still be rather traditional. Saito, Tsukui and Tanaka (2008) conducted their research in Vietnam primary schools and the results indicate that children-centred education, which is mandated by the government policies, has not been achieved in actual school practices. Another study in secondary schools (Ng & Nguyen, 2006) reveal that the teaching methods in science are teacher-centred and non-constructivist. The findings of the research conducted by Ng & Nguyen (2006) also reveal a shortage of equipment for students to do experimental work at secondary schools. Of the teachers, 90% participating in the research state that their students have not performed any experiments while learning science.

Pham (2010) writes that although Vietnam's tertiary education is strongly pushed by radical reforms of the government, the implementation of a student-centered approach in Vietnamese tertiary education institutions has failed. The reasons for this failure are argued by Pham (2010) to be cultural barriers and limitations of infrastructure. She explains that Confucian philosophy has a powerful influence on the attitudes and behaviors of the Vietnamese; as a consequence, the cultural barriers prevent the students-centered approach being implemented successfully in Vietnam. According to Pham (2010), the barriers include strongly held views that: (1) students receive knowledge from teachers, (2) students do not express their point of view in classes, and (3) Vietnamese students generally are passive and surface learners. Besides the cultural barriers, the limitations of infrastructure such as big classes and restriction of learning resources also contribute to the failure. Pham (2010) states that textbooks are used as the only learning resources in most Vietnamese universities, and the teachers require the students to read texts on a specific topic in the appointed textbook, but not seek information from other resources. The students, in this case, are not encouraged to discover knowledge from different sources of information where different points of view on the topic are presented.

Stephen, Doughty, Gray, Hopcroft and Silvera (2006) conducted a research project on Vietnamese universities, and this report also indicates that teaching methods are still traditional and not interactive:

> Ineffective teaching methods, which have too high a dependence on lectures and little use of active learning techniques (e.g., graded homework and class discussions), result in not much interaction between faculty and students in or outside of the classroom. Many faculties do not seem to hold office hours (Stephen et al., 2006, p. 10).

In addition, Stephen et al. (2006) find that an overemphasis on rote memorization of factual knowledge and a lack of emphasis on conceptual learning or higher order learning (e.g., analysis and synthesis) result in surface learning rather than deep learning. Students also learn passively, they listen to lectures, take notes, and reproduce memorized information on exams.

1.4.2 Students' Lack of Critical Thinking

1.4.2.1 Definition of critical thinking

There are various definitions of critical thinking. Ennis (1989) defines critical thinking as reasonable reflective thinking while E. A. Bell (1991) considers critical thinking to include justification and discovery. Brookfield (1987), on the other hand, believes critical thinking comprises discovering and checking assumptions, as well as making decisions based on these assumptions. Kurfiss (1988) views critical thinking as investigating a situation, or a problem or a phenomenon. The definitions of critical thinking are diversified, and there was substantial confusion about them (Simpson & Courtney, 2002).

By the end of 1990s, the American Philosophical Association started to make systematic research on critical thinking and critical thinking assessment with the launch of the Delphi Project led by Facione (Facione, 1990b; Simpson & Courtney, 2002). Under the Delphi Project, a panel of 46 leading experts in the critical thinking research area agreed on a definition of critical thinking (Wegerif, 2002) which consists of two dimensions (i.e. cognitive skills and affective disposition).

> We understand critical thinking to be purposeful, self-regulatory judgement which results in interpretation, analysis, evaluation and inference as well as explanation of the evidential, conceptual, methodological, criteriological or contextual considerations upon which that judgement was based. Critical thinking is essential as a tool of inquiry... The ideal critical thinker is habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit (Facione, 1990b, p. 3)

The Delphi experts also identified core critical thinking skills which include (Facione, 1990b, 2010):

- interpretation (e.g. categorization, decoding significance and clarifying meaning)
- analysis (e.g. examining ideas, identifying and analysing arguments)
- evaluation (e.g. assessing claims and arguments)

- inference (e.g. querying evidence, conjecturing alternatives and drawing conclusions)
- explanation (e.g. stating results, justifying procedures and presenting arguments)
- self-regulation (e.g. self-examination and self-correction)

While interpretation skill involves in the comprehension of the meaning, analysis focusses on identifying relationships. Evaluation skill then concentrates on the assessment of the credibility of statements and the logical strength, and inference relates to finding relevant information and elements to support for conclusions and the formation of hypotheses. Explanation skill consists of presenting arguments and results as well as justifying the procedures. Lastly, self-regulation involves in the thinking skill of self-assessment and self-correction.

1.4.2.2 Vietnamese students’ critical thinking skills

While critical thinking is considered one of the foci of education by many countries in the world including USA, UK, Canada, Australia and New Zealand (Halpern, 1998, 1999; Pithers & Soden, 2000), Vietnamese students lack critical thinking skills (C. Nguyen, 2012; Stephen et al., 2006).

At the request of the Minister of Education and Training, an undergraduate education project was conduct by Stephen et al. (2006) with the support and cooperation of Vietnam’s MOET, the National Academies of the United States, Vietnam Education Foundation and Southeast Asian Ministers of Education Organization Regional Training. One of the project aims was to investigate the teaching and learning in Vietnamese universities. The project reported that undergraduate programmes do not prepare Vietnamese students with critical thinking skills and other skills for their future careers.

> Preparation is lacking in common or professional skills such as oral and written communication and presentation skills, team work, problem solving, project management, critical thinking, and self-confidence (Stephen et al., 2006, p. 14).

The report of this project advises that Vietnamese under graduate programmes need to focus on the development of students' critical thinking skills. Harman and Nguyen (2010) also suggest that it is necessary for Vietnamese tertiary education programmes to assist students to develop their critical thinking skills because these skills are very important for them in the information-based global setting.

1.5 Rationale of the Research

In order to support industrialising and modernising the nation as well as to fulfil the learning needs of Vietnamese people and the requirements of globalisation, MOET under the supervision of Vietnam's Prime Minister has implemented primary, secondary and tertiary educational reforms. Some of the reform objectives are ("Chỉ thị số 14/2001/CT-TTg về đổi mới chương trình giáo dục phổ thông thực hiện nghị quyết số 40/2000/QH10 của quốc hội [Directive no. 14/2001/CT-TTg on secondary educational program reform for the application of the resolution no. 40/2000/QH10 of the national assembly] (Vietnam)," 2001; "Nghị quyết 14/2005/NQ-CP về đổi mới cơ bản và toàn diện giáo dục đại học Việt Nam giai đoạn 2006 - 2020 [The resolution no. 14/2005/NQ-CP on fundermental and comprehensive higher education reform in Vietnam for the period of 2006 – 2020] (Vietnam)," 2005):

- to innovate teaching and learning methods,

- to use information communication technology in teaching and learning.

Implementing ICT into teaching and learning as well as innovating teaching and learning methods has become a policy of Vietnam's government ("Nghị quyết 14/2005/NQ-CP về đổi mới cơ bản và toàn diện giáo dục đại học Việt Nam giai đoạn 2006 - 2020 [The resolution no. 14/2005/NQ-CP on fundermental and comprehensive higher education reform in Vietnam for the period of 2006 – 2020] (Vietnam)," 2005; "Nghị quyết của quốc hội nước Cộng Hòa Xã hội chủ nghĩa Việt Nam số 40/2000/QH10 ngày 09 tháng 12 năm 2000 về đổi mới chương trình giáo dục phổ thông [The resolution of The Socialist Republic of Vietnam National Assembly no. 40/2000/QH10 December 09th, 2000 on secondary educational programme reform] (Vietnam)," 2000). The innovative act is top-down and nation-wide. However, this innovative act seems not to be effective. Although the Vietnam's government has invested significant amount of money into providing Vietnamese schools with technology equipment, a teacher-centred approach still dominates Vietnamese classrooms (Ng & Nguyen, 2006; Pham, 2010; Saito et al., 2008; Stephen et al., 2006).

It is argued by Harman and Nguyen (2010) that Vietnamese teachers are now facing the challenges of technology-driven education; the critical need for teachers in this context is to acquire new understanding and skills in using ICT to support teaching in the light of a student-centred approach. However, there is very little literature which could inform Vietnamese teachers on how to use ICT underpinned by a student-centred approach in their teaching context.

The researcher is a Vietnamese lecturer teaching physics and training pre-service and in-service teachers at secondary schools on how to use ICT pedagogically.

During the process of teaching and training, an essential need arose in her own teaching practices as mentioned in Section 1.1: in the form of a theoretical pedagogic framework for integrating appropriate learning theories with ICT for the teaching of Physics. Nevertheless, it seems that there is no searchable literature or research in the field which has been conducted in the Vietnamese context.

The goal of the research, based on this perception was to develop, trial and evaluate a pedagogic model which integrates appropriate learning principles with ICT for the teaching of Physics in the context of Vietnam.

When the model was developed, it was then necessary to have some criteria to judge if it was an effective pedagogic model. As one of the current issues to be addressed in Vietnamese education system was a teacher-centred approach to pedagogy, with low teacher-student interaction, the first criterion identified in this case was increasing interaction within a learning environment. The second issue, referred to earlier, was students' lack of critical thinking skills; consequently, the second criterion was enhancing students' critical thinking skills. Another criterion, which was compulsory for any physics teaching model, was improving students' physics test scores. In general, an effective pedagogic model was defined in this research as a model which can help to:

- increase interaction within a learning environment,
- improve students' physics test scores, and
- enhance students' critical thinking skills.

These three criteria which were derived from the research goal were specified in three research questions:

1. In what ways does the application of the pedagogic model increase interaction within the learning environment?

2. Does the application of the pedagogic model improve students' physics test results?

3. In what ways does the application of the pedagogic model enhance students' critical thinking skills?

1.6 Overview of the Thesis Chapters

This thesis includes seven chapters. Chapter one presents some key points about the context of Vietnamese education. It also argues the rationale of this research. Based on the needs of the Vietnamese context, the research goal and research questions are identified.

Chapter two presents the journey of seeking a suitable pedagogic model which integrates appropriate learning principles with ICT in teaching Physics in the context of Vietnam. First, some basic concepts which associate with the thesis are explained. The chapter then addresses the argument why constructivist learning principles were included in the theoretical pedagogic model. The first version of the theoretical pedagogic model is also presented and explained in this chapter.

Chapter three explains the research methodology. It begins with the discussion of the research paradigms, the analysis of the strong points and weaknesses of the data collection methods which originate from the paradigms. Based on this analysis, the researcher argues her decision on choosing certain data collection methods. The research goal, research questions and framework are then presented. The chapter also describes the research participants, data collection and data analysis methods. Triangulation is the focus and the spirit which run through the whole research.

Chapter four addresses the development of the theoretical pedagogic model. First, the chapter describes the process of conducting expert evaluation of the model. The analysis of the experts' comment and the critique of their evaluation are presented. The revision of the model is displayed. The revised model is then explained based on further literature review.

Chapter five discloses the findings from the data analysis results. The findings are organized accordingly to the data sources. The reason for this way of organizing the findings is to present detailed data analysis results from each source of data. These detailed results could provide the readers with background information supporting for their judgments on the triangulation of findings which is presented by the end of Chapter five.

Chapter six discusses the findings which are organized accordingly to the research questions. The findings from different data sources and different groups of people involved in the research are triangulated. The chapter also reflects the research findings upon the literature and the results of other studies, as well as discusses these findings under the lens of the CSI Model.

Chapter seven concludes this research. It examines if the research goal has been fulfilled and answers the research questions. The chapter ends with some recommendations for teaching practices and further research directions in the field.

Chapter 2 Literature Review

The previous chapter presented relevant features of the Vietnamese context, the rationale of the research and the research goal. This chapter will present the basic concepts which relate to this research such as ICT, the scope of ICT and learning theories. The chapter will then outline the journey of seeking a suitable pedagogic model. This journey covers an investigation of constructivism, ICT and learning. It also covers the review of models of integrating ICT in education as well as their utility. Finally, the first version of the theoretical pedagogic model, which was constructed based on the reviewed literature, will be explained.

2.1 Information Communication Technology and Learning

2.1.1 Information Communication Technology in General

Information and communication technology (ICT) is defined by UNESCO as forms of technology used for creating, displaying, storing, manipulating, and exchanging information (Meleisea, 2007). This broad definition includes all forms of information communication technology. ICT today is commonly thought of relating to electronic and digital form of technology such as computers, networks, e-mail, internet, telephone, television, radio and so forth.

In the 1960s and 1970s, school and university teachers started to use television, radio, overhead projectors and movies in their teaching. Since personal computers and the internet were developed in the late 1980s and early 1990s, the use of ICT in education has grown rapidly. Caladine (2008) categorized the history of technology use in learning as several generations, which were considered as generations of distance education by Taylor (1995) (see Table 2.1).

Table 2.1 *History of ICT in Learning*

Generation	Associated Technologies
First Generation The Correspondence Model	Print
Second Generation The Multi-media Model	Print Slides Audiotape Videotape Computer-based learning Interactive video (disk and tape)
Third Generation The Tele-learning Model	Audio-teleconference Videoconference Audiographic Communication Broadcast TV/Radio
Fourth Generation The Flexible Learning Model	Interactive multimedia Internet based access to www resources Computer mediated communications
Fifth Generation The Intelligent Flexible Learning Model	Interactive multimedia online Internet based access to www resources Computer mediated communications, using automated response systems Campus portal access to institutional processes and resources
Sixth Generation Web 2.0 e-learning 2.0	Social software Student creation of resources Sharing experience and resources Media rich

(Caladine, 2008)

In the first and second generations (the 1960s and 1970s), the application of ICT included printed material, slides, audiotapes, videotapes and computer-based learning (Caladine, 2008; Ipek, Izciler, & Baturay, 2008; Nippers, 1989). Technological teaching aids were used in the delivery of learning materials in the classroom and in distance education. Not until the third generation did people start to use ICT as a tool for interaction in teaching and learning.

In the late 1980s and 1990s, the proliferation of personal computers and the Internet resulted in significant changes in the implementation of ICT in education. In the fourth and fifth generations, ICT not only included learning resources but also tools to facilitate interaction and collaboration (Caladine, 2008; Taylor, 1995). Learning management systems such as Blackboard and WebCT became widespread. The implementation of online interactive multimedia, internet based access to internet resources, computer mediated communications, automated response systems, and campus portal access to institutional processes and resources provided a highly interactive and flexible learning environment for students.

The sixth generation differs from the other generations due to advanced interactive delivery and advanced interactive environments (Caladine, 2008). The striking features of the sixth generation are the use of learning materials produced by learners, the use of social software (e.g. blogs and wikis) and the growth of shared multi-media resources. The sixth generation typifies the change between Web 1.0 and Web 2.0. Web 1.0 refers to the first generation of the Web that is concerned with posted information. The second generation of the web (Web 2.0) allows users to contribute to the web (Downes, 2005). For example, social networking sites (e.g. FaceBook, Flicker and Yahoo360^0) permit people to create their own profiles and upload information including texts, photos, pictures, audio and video files. The users can also add, edit and remove the content. Wikipedia is another example of Web 2.0 which is written collaboratively by users.

2.1.2 The Scope of ICT in this Research

As mentioned above, ICT has a broad meaning. This section will present a narrower scope of ICT which is investigated in the research. The focus of ICT in this study is the use of Internet, software, multimedia resources, course management systems and computer-based testing systems in education. The applications of ICT are categorised into three groups: learning resources, instructional organisation of learning, and communication (see Table 2.2).

The applications of ICT in learning resources include educational software, distributed resources via the Internet and video resources. Educational software is not only learning resources for students but also tools for the instructional organisation of learning. For example, in the area of physics education, available software includes Physics Pro, Crocodile Physics and Andres Physics. Rich learning resources distributed via the World Wide Web and video resources are also considered as important learning resources.

The next category, instructional organisation of learning, includes the three areas: software and technology tools supporting lectures, course management systems and computer-based testing systems. In the first area, educational software and technology equipment are needed to assist in face-to-face lectures such as the teaching and learning software mentioned above. The tools supporting lectures in class include LCD projectors, computers, speakers, over-head projectors, and so on. The second application of ICT in instructional organisation of learning is course management systems (e.g. Blackboard, Moodle, WebCT...). Course management systems are also called learning management systems, e-learning systems, content management systems, managed learning environments or learning support systems. The third area includes computer-based testing systems such as Maplesoft T.A. and Hot Potatoes, which are applied in the instructional organisation of learning.

Table 2.2 *The Application of ICT in This Study*

Categories	The applications of ICT
Learning resources	Educational software Distributed resources via the internet Video resources
Instructional organisation of learning	Software and technology tools supporting face-to-face lectures Course management system Computer-based testing system
Communication	E-mail system Websites offering communication options for the direct sending for e-mail and forms of structured communication Software system for text-based chat

(Collis & Moonen, 2001)

ICT is also utilised to promote communication. The use of ICT in this domain, consisting of e-mail systems, websites, and software systems for text-based chat, offers different communication options.

In general, ICT embraces many forms of technology. This research limits its exploration of ICT in terms of internet, software, multimedia resources, course management systems and computer-based testing systems. The applications of

ICT are categorised into three groups relating to three vital factors of the education process: learning, instructing and communicating (student-student and student-teacher).

2.2 Learning Theories

While Section 2.1 presented the definition, history and the scope of ICT, this section will briefly review key learning theories. First, the historical role of behaviourist learning theory will be outlined, together with its limitations. The section will continue with a review of Cognitive and constructivist theories, and then conclude with a discussion of sociocultural theories.

2.2.1 Behaviourist Learning Theory

Behaviourist learning theory was the outcome of early experiments to study, observe, measure, repeat and replicate research on learning (Harasim, 2012). Important proponents of behaviourist learning theory are Pavlov, Watson and Skinner (Krause, Bochner, Duchesne, & McMaugh, 2010; Schunk, 2000). From a behaviourist point of view, learning is considered as the conduct of new behaviours based on stimulus and response associations (Harasim, 2012; Krause et al., 2010; Pavlov, 1960; Pritchard, 2014; Skinner, 1950, 1985). At its time (early 1900s), behaviourism was a dominant learning theory, but further research indicated key limitations:

- Behaviourism does not acknowledge the role of people’s thought and cognitive processes in learning (Hassan, 2011; Krause et al., 2010; Schunk, 2000; Skinner, 1985).
- It cannot explain many social behaviours (Harasim, 2012).

2.2.2 Cognitive Learning Theory

Cognitive learning theory recognises the contribution of behaviourism (Bruner, 1990) and addresses one of the key limitations of behaviour learning theory by focussing on the role of the mind's cognitive processes (Krause et al., 2010). It indicated that "cognitive processes were equated with the programs that could be run on a computational device" (Bruner, 1990, p. 6). Human information processing is considered to equate to computerised information processing: receiving, storing and retrieving information (Harasim, 2012). All cognitive activities such as remembering, rehearsing, imaging, thinking and problem solving relate to information processing (Schunk, 2000). Information processing also became a theoretical foundation for problem-based learning (Hmelo-Silver & Eberbach, 2012; Hung, 2011; Schmidt, 1993), which is an instructional method developed in 1960s (Lam, 2004; Schmidt, 1983; Smits, Bouhuijs, & Perrenet, 2000). Problem-based learning was then developed beyond the foundation theory, and came be recognized as an instructional method underpinned by another learning theories.

Despites the differences, cognitivists and behaviourists share a common pedagogy: both theories are teacher-centred (Harasim, 2012). In contrast to behaviourist and cognitive learning theories, constructivist learning theory provides a theoretical background that promotes a student-centred approach.

2.2.3 Constructivist Learning Theory

Constructivism is a theory about how human beings construct knowledge (Salomon & Perkins, 1996; Von Glasersfeld, 1989). The original conception of constructivism comes from Giambattista Vico, an Italian philosopher, humanist and rhetorical theorist who was born in the 1600's (Duffy & Cunningham, 1996).

The fundamental idea of Vico's is that human beings only know the knowledge which they have constructed. From Vico's point of view, to know means to know how to make or how to create. Human beings did not create the real world so they do not understand how the real world is (von Glasersfeld, 1998). There are a range of views and much research on learning and teaching from a constructivist perspective (Watts & Pope, 1989). However, the general constructivist view of learning can be presented as: learning is not the result of transmitting knowledge, but a process of individuals actively constructing knowledge based on their experience, and the teachers' role is to support their knowledge construction (Driver & Oldham, 1986; Duffy & Cunningham, 1996; Ozkal, Tekkaya, Cakiroglu, & Sungur, 2009; Rovai, 2004). Driver and Oldham (1986) outline the key constructivist notions about learning as:

- Individuals actively and purposively interact with their environment in the learning process rather than passively respond to the environment.
- Individuals construct their knowledge through social interaction.
- Individuals' knowledge is actively constructed in a given situation and is influenced by their prior knowledge and beliefs.

(Sewell, 2002) notes that constructivist learning theory may be a useful theory for teachers; implementing the theory in teaching practices could help teacher to identify student misconceptions as well as to assist students overcome these misconceptions. Related to constructivist learning theory is experiential learning theory (A. Y. Kolb & Kolb, 2005). From the experiential view, "learning is the process whereby knowledge is created through the transformation of experience" (D. A. Kolb, 1984, p. 38). Based on the work of prominent constructivists such as Dewey and Piaget, experiential learning theory shares a common view with constructivist theory in that learning is a process of constructing knowledge influenced by learners' prior knowledge, experience and belief. Experiential learning involves four modes of grasping and transforming experience: concrete experience & abstract conceptualisation, reflective observation & active experimentation; and the relationship within each pair of modes (i.e. concrete experience - abstract conceptualisation, reflective observation - active experimentation) is dialectical. (A. Y. Kolb & Kolb, 2005; D. A. Kolb, Boyatzis, & Mainemelis, 2011).

2.2.4 Sociocultural theories

Based on the constructivist theory, sociocultural theories seek insight into learning in a sociocultural environment. Similar to constructivist views, sociocultural views are diverse. Sociocultural views of learning could be summarised in five main themes:

- Learning is participating in a social process of knowledge construction (Cobb & Bowers, 1999; Cole, 1995; Greeno, 1997; Lave & Wenger, 1991).
- Knowledge (cognition or intelligence) is distributed across social systems, between and among people, learners, cultures, artifacts, environments and situations (Cole & Engeström, 1997; Pea, 1997; Salomon & Perkins, 1996; Salomon & Perkins, 1998).
- Learning is situated in contexts and activities (Brown, Collins, & Duguid, 1989; Greeno, 1997; Lave & Wenger, 1991).
- Learning is mediated by artifacts and cultural tools (Salomon & Perkins, 1998; Wertsch, 1991, 1994; Wertsch, Río, & Alvarez, 1995).

- Learning is goal-directed (Cole, 1985; Engeström, Miettinen, & Punamäki, 1999; Vygotsky, 1978; Wertsch, 1985).

Within the sociocultural umbrella, activity theory “presents the idea that activity systems are basic units of analysis” (Cole & Engeström, 1997, p. 8). Activity theory, which illustrates the unit of analysis, proposes that cognition (intelligence or knowledge) is distributed (Cole & Engeström, 1997), and also emphasizes on goal-directed feature of actions (Cole & Engeström, 1997; Engeström et al., 1999).

Sociocultural theories emphasize the role of interaction and cooperation in learning processes (Cobb & Bowers, 1999; Cole & Wertsch, 1996; Greeno, 1997). In line with sociocultural perspectives, social interdependence theory explains how cooperation affects individuals in achieving their goals. There are two types of social interdependence: positive and negative interdependence. While positive interdependence promotes interaction and assists individuals achieving their goals, negative interdependence results in negative effects on individuals’ goal achievements (Johnson & Johnson, 2009).

2.3 Constructivism, ICT and Physics Teaching and Learning

Section 2.2 reviewed key points of learning theories, each having its own strengths and is appropriate for certain contexts and situations. As mentioned in Section 1.1, constructivism is promoted by the university where the researcher worked. The goal of this research is to develop, trial and evaluate a pedagogic model which integrates appropriate learning principles with ICT in teaching Physics in the context of Vietnam. The pedagogic model needs to be suitable for the Vietnamese context. This model is trialled at the university where constructivism is promoted. Therefore, it would seem to be useful to examine the integration of constructivism and ICT as well as investigate potential usefulness of the integration to support students' physics learning.

2.3.1 Students' Learning

Many empirical studies have been conducted regarding constructivism and education generally, and constructivism and physics learning and teaching specifically. The results of these studies show that constructivism as a learning principle can promote students' learning (Driver, 1988; Kamali-Mohammadzadeh, Behzadi, Shahvarani, & Hosseinzadeh-Lotfi, 2014; Ojugo, Osika, Iyawa, & Yerokun, 2013; Ozkal et al., 2009; Rovai, 2004). Furthermore, research seems to indicate that the integration of constructivism and ICT in teaching is able to enhance students' physics learning (Christina & Dimitrios, 2008; Driver & Scott, 1996; Fazio, Sperandeo-Mineo, & Tarantino, 2004; Iofciu, Miron, & Antohe, October, 2011; Rodrigues, Pearce, & Livett, 2001; Soong & Mercer, 2011; Tekos & Solomonidou, 2009; Wang, 2009)

Wang (2009), for example, conducted research on a teacher training programme in the National Institute of Education, Singapore. The researcher designed a web-based constructivist learning environment which focused on pedagogical, social and technological perspectives. The interaction between learners in the group, and between the instructor and the whole class was supported by technology (especially the Moodle learning management system). Group work, online discussion and a Q/A forum were used to promote social interaction. The findings indicated that discussion and collaboration helped learners build social relationships. The participants were engaged in different kinds of social activities such as seminars, group collaboration, group discussions and whole class discussions. The findings indicated that the constructivist learning environment helped the learners collaboratively construct their knowledge effectively.

Driver and Scott (1996) implemented constructivist principles in a project which was part of Secondary Science Curriculum Review in the United Kingdom. This action research about teaching Physics was conducted in three phases: preparatory, development and field-testing. Constructivist principles were implemented at different levels – learning environment, structure of the teaching sequences and learning activities. First, students were offered a supportive *learning environment.* The social organization of the class was focused on group-work to enhance student-student interaction and student-teacher interaction. Students were provided with opportunities to present their ideas and evaluate others' ideas. Teachers played the role of facilitators for the group-discussions. The second level was the *structure of the teaching sequences.* The sequences of teaching started from students' ideas. Information about the students' background was used in creating the learning activities. Then learners were provided with opportunities to reflect on the changes in their knowledge. The third level was *learning activities*. The designed learning activities were based on students' prior knowledge. The practical and theory based activities required learners to think critically, to try out different solutions and to evaluate theories. The findings of the project indicated that the students were interested and encouraged by the constructivist teaching approach, and that the teachers also had positive responses to the teaching strategies which implemented constructivist principles. Moreover, the teachers were satisfied with having the effective theoretical principles to direct their teaching, and they continued applying the framework after the research project concluded.

Another example is a study carried out by Christina and Dimitrios (2008) in Greece, with 226 students from 13 primary, lower secondary and upper secondary school classes. The project evaluated the effect of a social constructivist educational software package named “Interactions between Objects” on students’ learning of Physics including conceptions about Newton’s third law, the concept of mechanical interaction and Newtonian dynamics. The software contained ten experiments that related to Newton’s third law, and that simulated the interaction between real-life objects. The students were involved in different learning activities, which helped them to construct knowledge such as predicting the forces and movements of objects, analysing force vector, creating their own models when facing a cognitive conflict situation, and collaborating with other students to find solutions. Christiana and Dimitrios‘s (2008) findings indicated that the social constructivist software increased the students’ performance in Physics. It resulted in positive outcomes by promoting conceptual changes, even in difficult scientific topics.

2.3.2 Students’ Thinking

Research also shows that the implementation of ICT in education, especially the applications of ICT assisting interactions and collaboration, can support students’ thinking skills (Giacumo, Savenye, & Smith, 2013; Livingston, Soden, & Kirkwood, 2004; McLoughlin & Mynard, 2009; Wegerif, 2002).

Wegerif (2002) notes that the applications of ICT in education usually relate to the development of students’ thinking skills. He recommends three ways of using ICT to develop these skills: ICT as a tutor, as a mind-tool and as a support for learning conversations. It is emphasised that:

> Using technology does not, by itself, lead to transferable thinking skills. The success of the activity crucially depends on how the technology is used. Much depends on the role of the teacher. Learners need to know what the thinking skills are that they are learning and these need to be explicitly modelled, drawn out and re-applied in different contexts (Wegerif, 2002, p. 3).

Wegerif (2002) suggests that using ICT to support collaborative learning as well as using ICT as a support and resource for dialogues is very effective to foster students' thinking skills. Similarly, Livingston et al. (2004) proposed that peer interaction is a component of developing thinking skills.

Giacumo et al. (2013) conducted research on 216 undergraduate pre-service teachers in USA. The research aimed at investigating the effectiveness of two scaffold types (i.e. instructors' facilitation prompts and discussion board grading rubrics) on students' demonstration of their thinking skills in online asynchronous discussion. Its findings showed that these types of scaffolding could help increase the students' thinking. The study which was conducted by McLoughlin and Mynard (2009) in Emirates also indicates that online forum discussion and the instructor's clear prompts are essential factors for facilitating students' thinking skills.

Al-Fadhli and Khalfan (2009) carried out a case study in Kuwait University – Kuwait – that investigated the impact of a constructivist e-learning environment on critical thinking skills of students. An e-learning environment based on constructivist principles was developed and implemented in an undergraduate course for two semesters (28 weeks). Four groups of undergraduate students participated in the research: two control groups and two treatment groups. The critical thinking skills were measured by the California Critical Thinking Skills

Test, which is composed on the following scales: analysis & interpretation, inference, evaluation and explanation, deductive reasoning and inductive reasoning. The study showed that the treatment groups generally performed better than the control groups, in some scales significantly better. The constructivist e-learning groups' total score and scores of five thinking skill variables were higher than those in the traditional groups, with one exception (see Table 2.3). The results of the study indicated that the constructivist e-learning environment generally had positive influence on the learners' critical thinking skills.

Table 2.3 *Mean of California Critical Thinking Skills Test by Critical Thinking Skills*

Variable	Traditional - mean	Constructivist E-learning - mean
Analysis	3.14	3.78
Inference	5.86	6.94
Evaluation	3.45	3.43*
Inductive	7.25	7.45
Deductive	5.15	6.19*
Total	12.45	13.63*

* $p < 0.05$ (Al-Fadhli & Khalfan, 2009)

Findings from a number of empirical studies (Fazio et al., 2004; Iofciu et al., October, 2011; Rodrigues et al., 2001; Soong & Mercer, 2011; Tekos & Solomonidou, 2009) show that constructivist principles and the use of ICT can be implemented successfully.

2.4 Pedagogic Models

Following the trend of applying ICT in education, Vietnam’s Ministry of Education and Training set an important goal for education reform: implementing information communication technologies (ICT) to promote teaching and learning ("Luật Giáo dục [Education law] (Vietnam)," 1998; "Nghị quyết 14/2005/NQ-CP về đổi mới cơ bản và toàn diện giáo dục đại học Việt Nam giai đoạn 2006 - 2020 [The resolution no. 14/2005/NQ-CP on fundermental and comprehensive higher education reform in Vietnam for the period of 2006 – 2020] (Vietnam)," 2005). ICT is, therefore, purposely becoming integrated into education in Vietnam. This integration is top-down and is being applied on a large scale. Emerging from this reform, an important issue arises in that: the applications of ICT have not resulted in the expected pedagogic effectiveness. Stephen, Doughty, Gray, Hopcroft and Silvera (2006) conducted a research project in Vietnamese universities, and this report indicates that teaching methods in science remain traditional:

> “Ineffective teaching methods, which have too high a dependence on lectures and little use of active learning techniques (e.g., graded homework and class discussions), result in not much interaction between faculty and students in or outside of the classroom” (Stephen et al., 2006, p. 10) .

Farrell and Wachholz (2003) and Peeraer and Van Petegem (2011) also reported that teachers seem to focus more on the use of technology itself rather than the pedagogic aspect of using ICT to promote students’ learning.

In order to enhance the use of ICT in education and help teachers to use it to promote students’ learning, a pedagogic model of integrating ICT in teaching, which is appropriate for the context of Vietnam, is needed.

2.4.1 Models of Integrating ICT in Education

As mentioned earlier, the focus of this study is the development and testing of a pedagogic model which integrates appropriate learning principles and ICT in teaching Physics in the Vietnamese context. A range of models for using ICT in education has been reviewed, and their utility has been examined. The reviewed models generally can be categorised into two main groups based on their utility. The first group of models focus on the implementation of ICT at an institutional level. Examples of this group are:

- 4-E Model (Collis, Peters, & Pals, 2001)
- ICT implementation models (Mooij, 2009)

The second group focus on the implementation of ICT at individual level. The examples of models that belong to this group include:

- TPCK Model (Mishra & Koehler, 2006)
- The generic model (Wang, 2008)
- SAMR Model (Puentedura, 2006)

This section will discuss these models. It will also examine the utility of the models in association with the goal of the current study.

2.4.1.1 4-E Model

The 4-E Model (Collis et al., 2001) presents four factors that are most influential in the educational use of new technology by an individual: effectiveness, ease of use, environment and engagement (*Figure 2.1*). Collis and Moonen (2001) explain that the Es can be expressed as four vectors, and that the 4-E vector sum refers to the possibility that an individual use ICT in education.

The education effectiveness (the first E) relates to gain from technology use. It can be learning effectiveness such as improved communication, new forms of valuable learning experiences, support to the existing curriculum, and improved capacity to individualise aspects of the learning experience. Education effectiveness may be interpreted as short-term pay-off such as efficiency gains, routine tasks associated with learning more quickly, and as long-term pay-off (the benefit for institutions or individuals). The difficulty or ease in making use of technology, the ease of use (the second E), also plays an important role in the acceptance of ICT innovations by a person in an education context. It relates to the convenience of access to computers, printers and networks. The ease of use is also associated with software features such as user-friendly interface, quick and easy – to – learn - software. The environment (the third E) vector represents institutional aspects: vision, support, the level of use within the organisation and readiness to change. Infrastructure, funding, incentives and experience with technology-related innovations are other organisational aspects that should be considered. The personal engagement with technology use for learning-related purposes (the fourth E) relates to personal interest in using new technology for academic purposes. Examples of engagement are the pleasure derived from using technology and prior experiences with using new technology.

If the vector sum of the four Es is high enough to reach the likelihood-of-use threshold, the individual will likely apply new ICT in her or his learning and teaching context.

The 4-E Model incorporates the main factors influencing the application of new technology products in teaching and learning. It is a useful model for leaders, managers, heads of institutions and deans of faculties who want to set up a network implementation of ICT in their institutions, schools and universities. Management and policy makers need to be aware of the factors impacting individuals' acceptance of ICT innovations. Based on this understanding, they can develop appropriate policies, create effective strategies, provide enough support, build necessary infrastructure, buy appropriate hardware and software, and build an effective support team for implementing ICT in education. The model also appears useful for educators in developing an understanding of features influencing their innovative use of ICT.

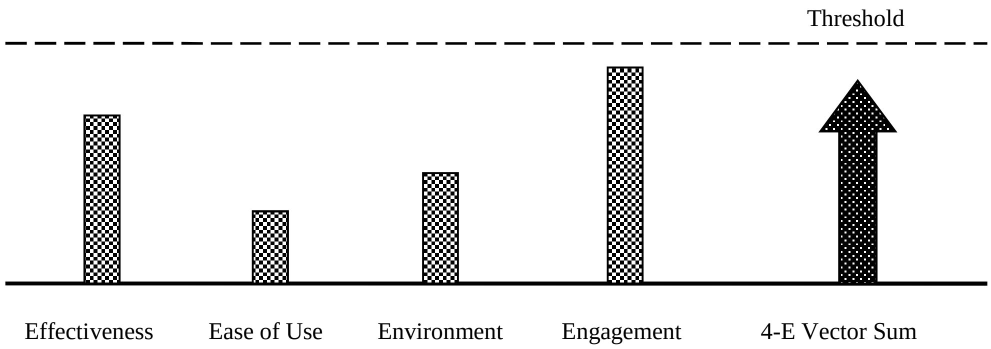


Figure 2.1 4-E Model

(Collis et al., 2001)

The 4-E Model, however, does not seem to meet the requirement of teachers who are seeking a theoretical framework to implement ICT efficiently. The teachers need to understand the nature of learning and to use ICT to support learning effectively. The 4-E model does not explain these issues; therefore, it tends to be more useful for leaders than for teachers who are looking for a specific model in integrating ICT in teaching.

2.4.1.2 ICT Implementation Models

Mooij (2009) suggests five models that reflect the five successive phases of implementing ICT into Dutch secondary school context. These models are:

- Model 1: incidental and sporadic use of ICT by one or more teachers
- Model 2: awareness of the relevance of ICT for the school and subject-related departments
- Model 3: ICT co-ordination and hardware facilities in the entire school
- Model 4: didactic innovation and ICT education support
- Model 5: integrated ICT support learning

In each model, the author identifies the actions and intervention conditions such as dissatisfaction with status quo, knowledge, resources, time, rewards, participation, commitment and leadership. An example of how Mooij (2009) outlines the intervention condition and actions is presented in Table 2.4.

The models that are presented by Mooij (2009) are able to inform managers of educational institutions (e.g. school principals, rectors and directors) on how to implement ICT into their institutes. They need to consider intervention conditions such as the current situation of their institutes, knowledge, resources, etc. as well as relevant actions related to their condition. However, these models do not inform teachers on how to implement ICT into their teaching practice.

Table 2.4 *ICT Implementation Model 1: Incidental and Sporadic Use of ICT by One or More Teachers*

Intervention condition	Action
Dissatisfaction with status quo	Address lagging behind in ICT area;
Knowledge	Disseminate information to enhance awareness of the relevance of ICT; organise or participate in an ICT seminar; focus on 'ICT literacy';
Resources	Allocate future budgets for hardware, software and training;
Time	Allocate time for information and training purposes;
Rewards	Hand out certificates to trained teachers or ICT-competent pupils;
Participation	Draft an ICT policy plan;
Commitment	Appoint an ICT co-ordinator and a system operator;
Leadership	Integrate ICT co-ordination into Senior Management

(Mooij, 2009, p. 279)

2.4.1.3 TPCK Model

Another model which appears popular for integrating ICT in education is the TPCK Model. The TPCK Model (Mishra & Koehler, 2006) describes the inter-relationships between content, pedagogy and technology, and then emphasises the importance of knowledge about the three areas in developing effective teaching.

Knowledge of *content* (C) in the model is an understanding about a subject matter. Teachers must be knowledgeable about the field of teaching, including facts, concepts, principles, theories, procedures and the structure of knowledge in their disciplines. *Pedagogical* knowledge (P) is knowledge about teaching and learning. Teachers also need to know the nature of learning; for example, how students construct knowledge and what a cognitive process is. Methods of teaching, student assessment, instructional design and classroom management are also contents of pedagogical knowledge. *Technological* knowledge (T) involves the awareness of and skills in operating technologies such as computer software, the Internet and LCD projectors.

Pedagogical content knowledge (PCK) existing in the intersection of content and pedagogy is the knowledge about teaching specific subject matter (Shulman, 1986). It is concerned with the arrangement of content, the representation and formulation of the subject, the analogies and demonstration of ideas in easily comprehensible ways to learners. *Technological content knowledge* associates with the application of technology in a subject matter. For example, statistics usually links to statistical computer software (e.g. Stata, R, and SPSS). *Technological pedagogical knowledge*, an overlapped area between technology and pedagogy circles, refers to abilities of using technology in an learning context. An understanding about existing technologies such as MS PowerPoint, digital camera and WebCT as well as the capabilities of utilising them and integrating them effectively into pedagogical sequences are illustrations of technology pedagogical knowledge.

As illustrated in *Figure 2.2*, in the centre of the model, *technological pedagogical content knowledge*, an emerged form of knowledge, is essential for successful application of ICT in teaching (Mishra & Koehler, 2006). It is the integration of teachers' understanding about subject disciplines and technologies related to the subject, knowledge about teaching and learning, and abilities of using existing technologies. Thus, technological pedagogical content knowledge is the knowledge of how to teach the content of subject matter through using technology to support pedagogy.

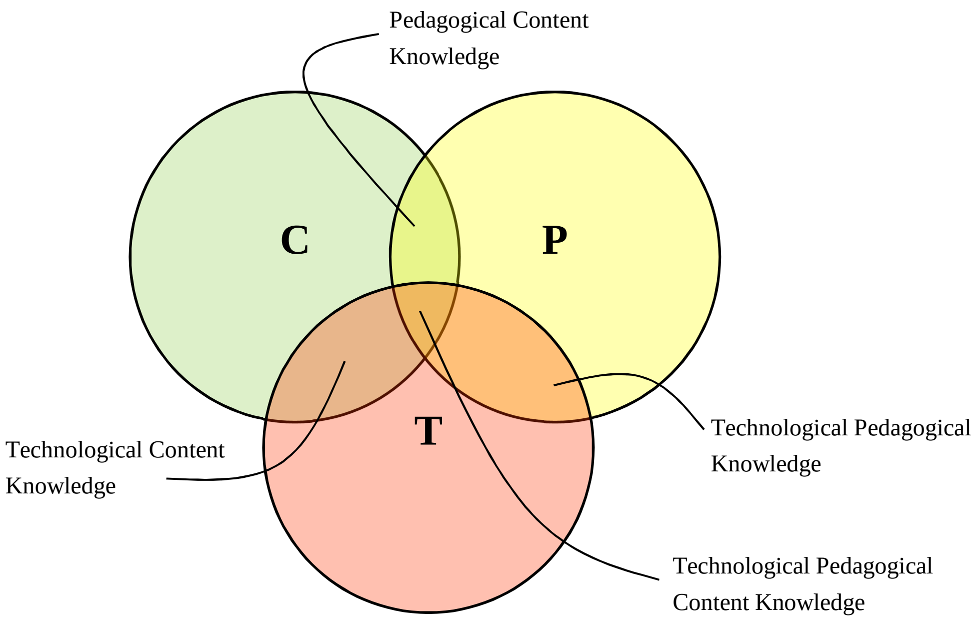


Figure 2.2 Pedagogical Technological Content Knowledge

(Mishra & Koehler, 2006)

The TPCK Model is a valuable theoretical conceptual framework for pre-service teacher training and teachers' professional development. The framework suggests that an over-emphasis on technology skills for teachers is not a wise solution, and that technology content knowledge, technology pedagogical knowledge and technology pedagogical content knowledge are all essential for success in implementing ICT in education.

The TPCK Model is a useful guideline for teacher educators and leaders of schools to develop professional knowledge, attitudes and skills for teachers. Nevertheless, it does not indicate how teachers apply ICT in their teaching practice. In the context of this research, specific guidelines based on a detailed theoretical framework for the implementation of ICT are required. Therefore, the TPCK Model is not directly used as theoretical framework in this research.

2.4.1.4 The Generic Model

The generic model is presented by Wang (2008) (*Figure 2.3*). According to Wang (2008), this model functions as a guide for teachers in effective implementation of ICT into teaching and learning. The model comprises three important components: technology, pedagogy and social interaction. Wang uses constructivism as the theoretical foundation of the model and focuses on interactivity in a learning environment. The types of interactivity, according to Wang's point of view, are learner-content, learner-people and learner-interface.

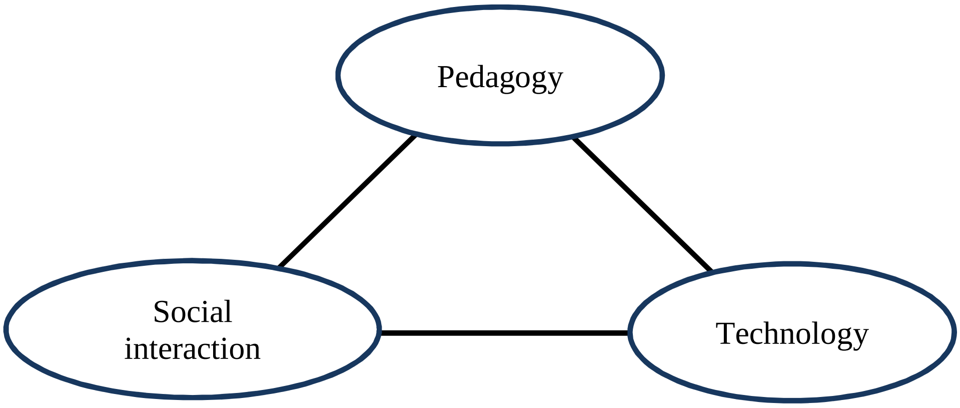


Figure 2.3 The generic model (Wang, 2008, p. 412)

The utility of the generic model for this research is the theoretical foundations of the model and the use of technology to promote social interaction. However, the model does not specify how constructivism relates to technology and pedagogy. The ideas that are suggested by Wang's model seem to be useful for the current research, but further elaboration is needed.

2.4.1.5 SAMR Model

The SAMR (Substitution, Augmentation, Modification, Redefinition) Model (Puentedura, 2006) maps four levels of integrating technology with teaching and learning (*Figure 2.4*).

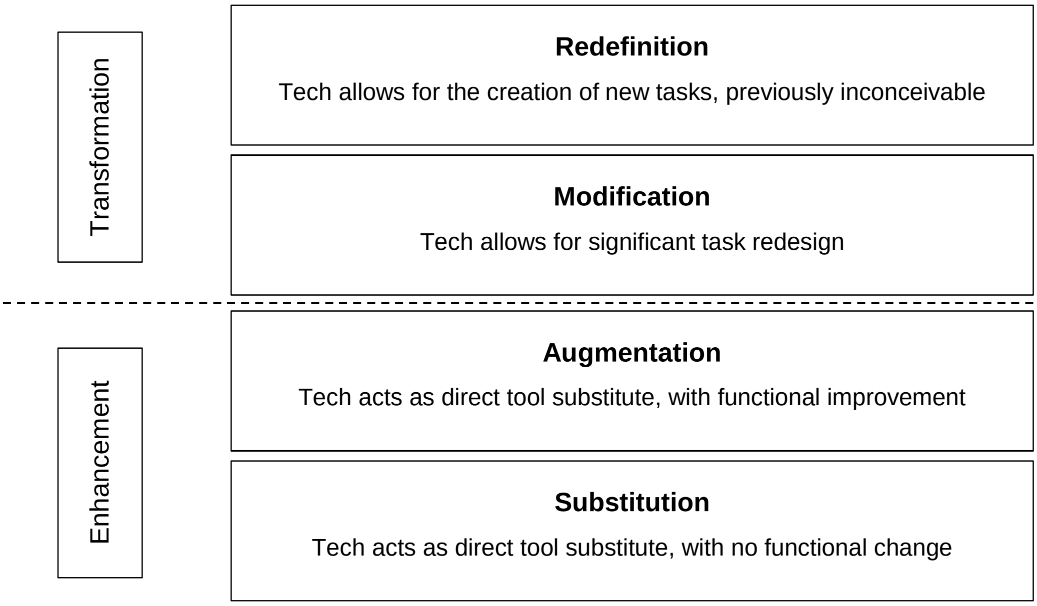


Figure 2.4 SAMR model

At the substitution level, technology is used as a new tool to replace what exists, but the task itself (e.g. writing) remains the same. For example, Google docs might be used to replace MS Word (Educational Technology and Mobile Learning, 2015). At the augmentation level, technology is used in a similar way as at the substitution level but with added functionalities, while the use of technology at modification level involves the redesign of the task. At the redefinition level, technology is utilised to create new tasks and to transform learning.

The idea of using technology at the modification and redefinition stages to transform learning seems to be a useful concept for this research, but again it does not specify the nature of the integration of ICT into teaching, but rather the general stages and the outcomes of implementation. In addition, this model originated from Puentedura's experience, not from his research (Green, 2014), and there is no background of research related to the design and development of the model.

2.4.2 Reflection upon the Models

Literature presents a range of pedagogic models for integrating ICT in education that can be categorised into two groups. The first group of models such as the 4-E Models and the ICT implementation models focus on the institutional level. The 4-E Model (Collis et al., 2001) presents four factors (four Es) that are considered to be most influential in the educational use of new technology by an individual: effectiveness, ease of use, environment and engagement. The Es can be expressed as four vectors. The higher the vector sum of the four Es, the greater chance that an individual will apply new ICT in her or his learning and teaching context (Collis & Moonen, 2001). The ICT implementation models, which is suggested by Mooij (2009), include five models. Each model focusses on intervention conditions (i.e. dissatisfaction with status quo, knowledge, resources, time, rewards, participation, commitment and leadership) and the appropriated actions relating to the condition.

These models appear to be useful for managers and policy makers who want to promote a network implementation of ICT in their institutions or countries. However, they do not seem to meet the needs of Vietnamese teachers who are seeking a theoretical framework to guide the efficient implementation of ICT in their daily teaching. They need to understand the nature of learning and use ICT to support learning effectively. These models do not explain these issues.

The second group of models focuses on individual teacher level. The TPCK Model, for example, (Mishra & Koehler, 2006) describes the inter-relationships between content, pedagogy and technology, and then emphasises the importance of knowledge about the three areas in developing effective teaching. Knowledge of content (C) in the model is an understanding about subject matter; pedagogical knowledge (P) is knowledge about teaching and learning; and technology knowledge (T) involves the awareness of and skills in operating. Technology pedagogical content knowledge is the knowledge of how to teach a subject using technology pedagogically. The TPCK Model is a valuable guideline for pre-service teacher training and teacher professional development. Nevertheless, the model does not provide specific and detailed guides for Vietnamese teachers who need a framework for applying ICT.

The TPCK Model is a standard guideline for teachers' professional development; the 4-E Model and the ICT implementation models of Mooij tend to be effective at institutional level. The models are functional; however, they do not meet the goal of this research.

Another example from the second group is the generic model which consists of three components (i.e. technology, pedagogy and social interaction). The ideas from the model could be useful for this research include social interaction and constructivism as theory foundations. The generic model informs teachers with guideline for designing an interactive learning environment:

> As a practical guideline, the design of the three components of the model can focus on learner–content, learner–people, and learner–interface interaction, respectively. For instance, the pedagogical design of an interactive learning environment can (1) make content meaningful, authentic, and relevant to learners and (2) allow

> learners to add further resources to share in addition to those suggested by a teacher. The social design of a learning environment ought to (1) involve more authentic tasks, group work, or project-based learning to promote interaction with peers, teachers and other experts, and (2) involve both synchronous and asynchronous communication, which can be implemented in forms of text, verbal chat or visual exchange (Wang, 2008, p. 414).

The ideas from this guideline are valuable for this research. The generic model supports students in socially constructing their own knowledge through social interactions. This model acknowledges individual differences; however, does not explain how technology supports students to individually construct their knowledge.

2.4.3 Constructivist Learning Principles in a Pedagogic Model

As mentioned in Chapter one, it is essential for Vietnamese teachers to have a pedagogic model to help them successfully implement ICT in teaching. Constructivist learning principles are chosen to underpin the use of ICT in the model for two main reasons.

The first reason is that research from a range of countries suggests that the applications of ICT in education, based on constructivist learning principles, can effectively enhance students' learning generally (Al-Fadhli & Khalfan, 2009; Beenakfer et al., 2004; Christina & Dimitrios, 2008; Driver, 1988; Driver & Scott, 1996; Ozkal et al., 2009; Rovai, 2004; Wang, 2009), and students' physics learning specifically (Driver & Scott, 1996; Fazio et al., 2004; Iofciu et al., October, 2011; Rodrigues et al., 2001; Soong & Mercer, 2011; Tekos & Solomonidou, 2009; Wang, 2009). In addition, the integration between constructivist principles and the use of ICT is able to promote students' thinking skills (Al-Fadhli & Khalfan, 2009; Wegerif, 2002).

The second reason for constructivist learning principles to be employed in the model is that the pedagogy currently underpinning the ICT applications of Vietnamese tertiary physics lecturers relate to constructivism (N. Nguyen, William, Nguyen, Nguyen, & Chantaranima, 2012). MS PowerPoint, MS Word and some simulation software are very commonly and frequently used in courses in Vietnamese universities while ICT applications as learning resources and communication to support learning (except e-mail) are not regularly used by teachers (N. Nguyen, Williams, & Nguyen, 2012; Peeraer & Van Petegem, 2011). The purpose of using MS PowerPoint and other software is to simulate and help students to visualise natural phenomena and experiments. N. Nguyen, Williams, et al. (2012) indicate that the pedagogical view underpinning the ICT applications in Vietnamese Physics undergraduate courses seems to be associated with a cognitive constructivist perspective which emphasizes students individually constructing their own knowledge.

Constructivist learning principles appear to be effective for incorporation into a pedagogic model of integrating ICT in teaching and learning. Moreover, Vietnamese teachers' pedagogy of using ICT in teaching seems to be based on a cognitive constructivist perspective. One important factor for successfully implementing a pedagogic model into Vietnam's universities is that the model has elements that are familiar to Vietnamese lecturers. Based on these two main reasons, constructivist learning principles are utilised in the pedagogic model developed in this thesis.

2.5 First Version of the Pedagogic Model

Based on current literature, a pedagogic theoretical framework has been created. The framework is built on constructivist learning principles. Knowledge, from the constructivist perspective, cannot be transferred from teachers to students but is constructed by students as individuals in a social environment. This environment may contain books, reading materials, learning tasks, curricula, teachers, peers and learning supporting tools (e.g. computers, experimental equipment, films, software and online course management systems) (von Glasersfeld, 2005).

There are approaches to constructivism: cognitive constructivism and social constructivism (Cobb, 2005). Each of these approaches reflects a fundamental aspect of human cognitive processes: internal re-organising of the cognitive system (Von Glasersfeld, 1989) and meaning making through social interaction (Salomon, 1998). The following sections will explain cognitive constructivism initiated by Piaget and social constructivism which originates from Vygotsky.

2.5.1 Cognitive Constructivism

As presented in Section 2.2.3, the conception of constructivism originates from Vico in 1600s. Two centuries after Vico’s time, Piaget significantly advanced constructivist theory (Driver & Oldham, 1986). According to Piaget, knowing is constructing and reconstructing knowledge. To know also means to produce in thought. The cognition process is the “optimizing equilibration” which brings us from “equilibrium” to new “equilibrium” (Bettencourt, 1993). This process may result in confirming or changing existing knowledge. During the cognition process, *schemes* (concepts, models, or patterns) are created by *assimilation* and *accommodation* (Von Glasersfeld, 1989). When confronting experience, human beings tend to judge the schemes, assimilate and integrate into current knowledge structures. Then the schemes become *assimilations*. When the assimilations are made, they are used many times. Three consequences of the repeated assimilations are the generalization and flexibility of the schemes, the integration of different schemes, and problems. When the problems appear, human beings start to notice the differences and make consequent perturbations in their cognitive activities. Based on concepts, models and patterns, they generate new solutions repeatedly until the new schemes give expected results. In this way, the schemes have been *accommodated*. Piaget states that assimilation and accommodation, which lead to a new equilibrium of knowledge, are two opposite poles of interaction between human beings and their environment in learning processes.

Piaget emphasises the inner process by which an individual human being constructs his/her own knowledge (Piaget & Gabain, 1932; Salomon & Perkins, 1996). Though social interaction sometimes happens, the schemes are constructed mainly by personal experience (Piaget & Gabain, 1932; Powell & Kalina, 2009) and cognitive organizers. This constructivist theory, which focuses on the individual constructing knowledge, is termed cognitive constructivism. Its role in science education is described by Grandy as “Cognitive constructivism has strong empirical support and indicates some important directions for changing science instruction” (Grandy, 1997, p. 51).

Cognitive constructivism explains how an individual human being constructs their own knowledge. However, human beings live in society, and many theorists propose that this social environment has an influence on learning; therefore, the social factors should also be taken into account in theorising the knowledge construction process (Cobb, 1994; Salomon, 1998; Von Glasersfeld, 1989). In the next section, roles of social factors in the process of constructing knowledge will be discussed.

2.5.2 Social Constructivism

The concept of social constructivism was developed originally by Vygotsky (Powell & Kalina, 2009). In social constructivism, collaboration and social interaction are assumed to play a very important role in the process by which learners construct knowledge (Von Glasersfeld, 1989). The cognitive constructivist view focus on the notion that learners individually construct knowledge in their own mind. The social constructivist view is based on the notion that learners interact with other human beings and environment in order to construct their own knowledge (Jonassen, Davidson, Collins, Campbell, & Haag, 1995). The learning processes not only relate to internal process of making meaning but also involve the process of social negotiation: “We debate, wrestle, and argue with ourselves over what is correct, and then we negotiate with each other over the correct meaning of ideas or events” (Jonassen et al., 1995, p. 12). By social interaction and negotiation, the learners conduct the processes of meaning making and create their own personal knowledge.

Cognitive constructivism focuses on how human beings as individuals construct knowledge; social factors are acknowledged but are not focussed. In contrast, social collaboration and interaction play a central role in social constructivism; understanding occurs through social activities. Learning is a process involving both the learners’ social interaction and their personal critical thinking process. Therefore, social constructivism and cognitive constructivism are two vital aspects of the learning process; they have a mutual relationship and cannot be separated (Powell & Kalina, 2009).

Figure 2.5 presents the pedagogic theoretical model which integrates constructivist learning principles and ICT. In general, the nature of learning can be enlightened by cognitive and social constructivist points of view: learning means creating and self-organising knowledge (cognitive constructivism) (Fosnot & Perry, 2005; Von Glasersfeld, 1989), and learning is a social process of interaction and making meaning (social constructivism) (Tobin & Tippins, 1993). Moreover, learning is facilitated by tools; one of which is ICT, an important tool which offers considerable learning flexibilities. By providing several options for students, ICT can be considered as an effective mean to support internal learning processes (individual aspect of learning) and a powerful tool to promote collaboration and interaction (social aspect of learning). The following section will explain the model in detail. Some sections of the diagrammatic framework in *Figure 2.5* will be reproduced again in order to locate the components in the model easily.

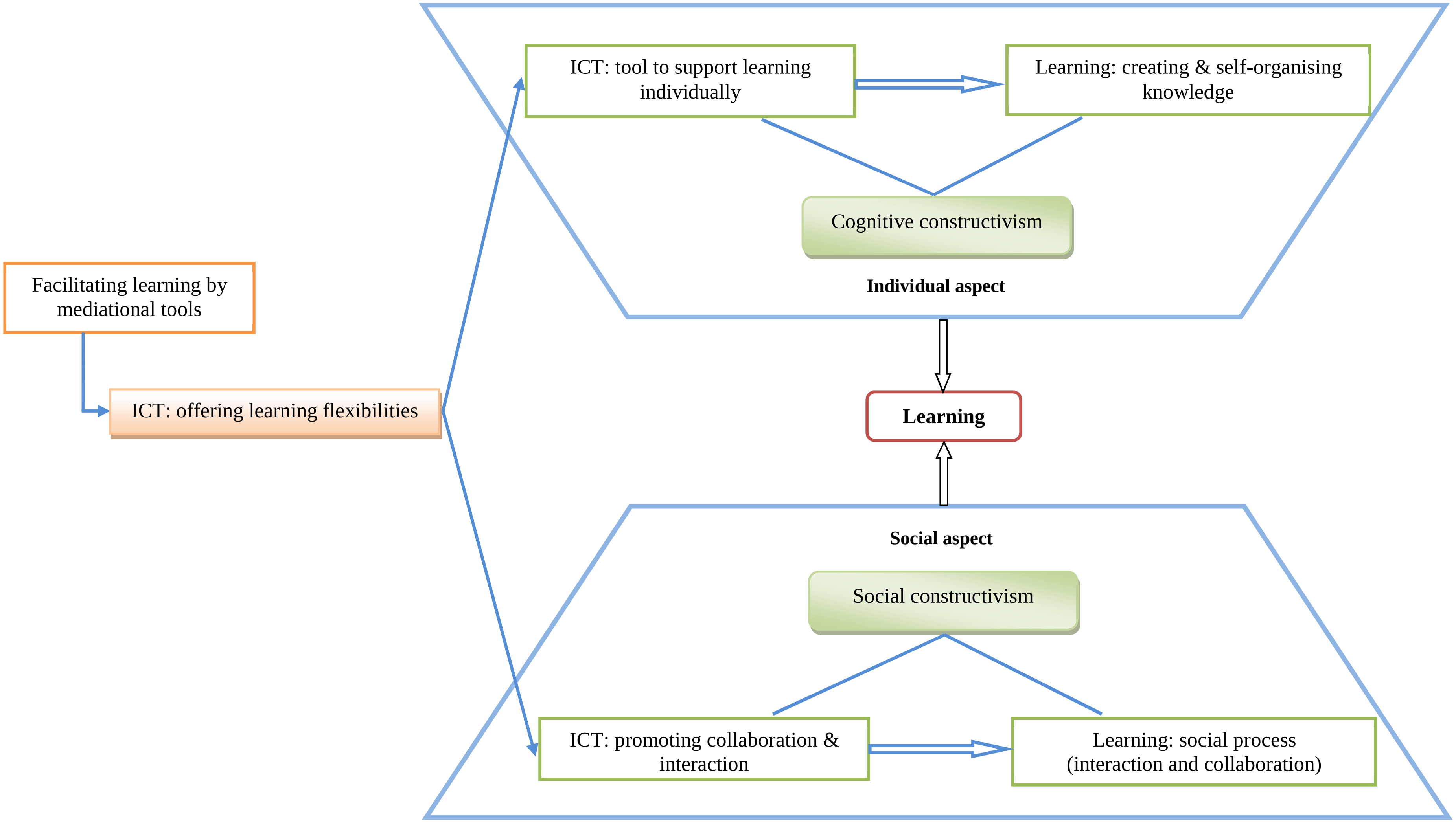


Figure 2.5 The Pedagogic Theoretical Model of Integrating Constructivist Learning Principles and ICT

2.5.3 Constructivist Learning Principles

Learning, which is in the centre of the diagram, consists of two aspects, individual and social. The nature of the personal aspect of learning is explained by cognitive constructivism; and the social aspect by social constructivism.

The first constructivist principle is that learners create and self-organise their own knowledge in order to learn (Fosnot & Perry, 2005; Von Glasersfeld, 1989) (*Figure 2.6*)**.** This first principle concerns the human internal process of constructing knowledge (cognitive constructivism). Learning normally starts by observing or experiencing, continues with making meaning and relating current experiences to cognitive systems which learners have previously developed. Learners then integrate or differentiate the new knowledge; thus, the new balance in their cognitive system is formed. Based on this theory of learning, teachers can facilitate student learning by offering them as many opportunities to observe and to experience as possible in a learning context (Watts & Pope, 1989). The teaching content should consider learners' prior knowledge (Driver & Oldham, 1986; Ozkal et al., 2009). Teachers need to provide appropriate help so that learners can relate new information to prior cognitive systems, then make the change and enrich their understanding.

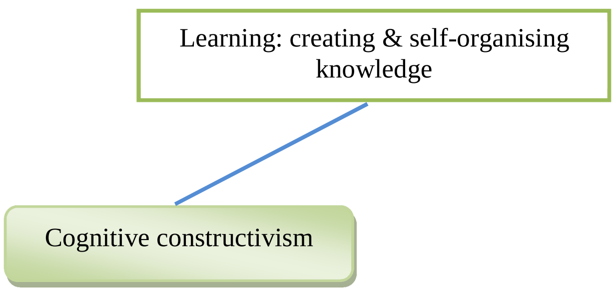


Figure 2.6 The first constructivist learning principle

The second constructivist learning principle is that learning is a social process (Tobin & Tippins, 1993) (*Figure 2.7*). Individuals construct their understandings in social settings. While the first principle focuses on the personal cognition component of the learning process, the second principle is directed at the social component of learning (social constructivism). Social interaction between learner-learner and learner-teacher plays an important role in the learning process. Students should be provided with a supportive, opened and interactive environment which helps them to discover knowledge. This learning environment facilitates learners to generate as many of their own hypotheses, models and possibilities as possible, including both affirmative and contradictory possibilities (Driver & Oldham, 1986). From the social constructivist perspective, students collaborate, share information, negotiate with each other and consequently make meaning (Jonassen et al., 1995; Von Glasersfeld, 1989). Therefore, the learning environment encourages students to present, discuss, negotiate their points of view with community, test their hypotheses, models or their possibilities, evaluate and restructure ideas and find out the viability (viable knowledge). Teachers should facilitate students' learning by providing them with opportunities to collaborate with others, to solve problems and to present to others their work, knowledge and skills. Teachers design learning tasks which direct learners' thinking and activities. Teachers play the roles of supporters, mentors or guides who foster students' learning. Students construct their own knowledge and skills through social interaction.

Cognitive constructivism focuses on the way an individual constructs their own knowledge. Based on this view, cognitive constructivist educators aim at design learning tasks for individuals so develop individuals' skills and knowledge. In contrast, social constructivism emphasises the interaction and participation involved in the learning process. Thus, social constructivist educators are concerned with designing group-work activities so that students have opportunities to participate and work in groups. Students interact and collaborate with each other when they engage in a learning task and so construct their knowledge and skills.

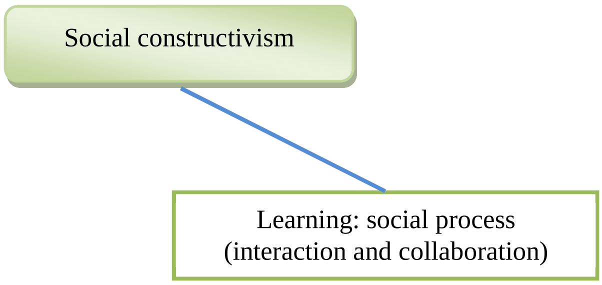


Figure 2.7 The second constructivist learning principle

Learning, from the cognitive constructivist point of view, is a process of creating a new balance of cognitive systems and re-organising knowledge; and, from the social constructivist perspective, a social process of interaction and meaning making. According to Salomon (1998), learning is the process involving both learners' social interaction and their personal thinking process; as a result, the two elements in the diagram have a mutual relationship, exist together and cannot be separated from each other. Cognitive constructivism and social constructivism complement each other and "present two sides of an ongoing dynamic process of reciprocal influences" (Salomon, 1998, p. 6).

2.5.4 ICT Facilitating Learning

Learning is facilitated by mediational tools, such as signs, diagrams, language, experimental equipment, technical tools and technology (Daniels, 2008) (*Figure 2.8*). The tools are powerful to enhance learning processes. They may direct thinking and may shape actions. The mediational tools will stimulate learners to construct their own knowledge in a social context if teachers use those tools effectively. For the purpose of the study, the tool information *communication technology* will be a focus.

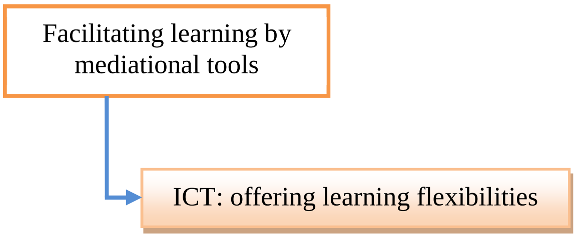


Figure 2.8 Mediational tools

ICT Offers Flexible Learning Environments for Students

A flexible learning environment usually means distance learning in common ways of thinking, yet flexible learning relates to many different choices for students such as time, topics and learning materials. Places where learners contact teachers and other learners are just one dimension of flexibility.

Collis and Moonen (2001) state that flexibility in learning concerns a variety of options for learners in the learning environment. In the current research, ICT is used to diversify options for students in terms of learning resources, instructional organisation of learning and communication. In addition, ICT is applied to support learners' choices of social organisations of learning and languages.

First, learners are provided with a wide range of learning resources, including traditional resources (e.g. textbook, library resources) and ICT resources (e.g. educational software, rich resources on internet and video resources). The flexibility in learning resources connects with three dimensions: topics, key learning materials and learning resources.

Second, the instructional organisation of learning becomes more flexible since face-to-face lectures, a course management system and a computer-based testing system are integrated. Software and technology tools are implemented in face-to-face lectures. The integration of face-to-face lectures, a course management system and a computer-based testing system provides learners with many alternatives for submitting assignments and interacting within a course. This integration permits them to decide the pace of study, choose instructional organisation of learning (e.g. face-to-face and online), time and place to contact teachers and other learners (e.g. in classes at fixed time or off campus during weekdays). Moreover, the application of ICT gives students choices of methods and technology for obtaining support and making contact.

Third, the implementation of ICT offers a range of alternative methods of communication such as face-to-face, e-mail, chat, forum and social networking websites. It enhances the flexibility of the social organisation of learning, time, location and methods of interacting.

Many studies focus on the use of social networks (e.g. Facebook, Twitter and LinkedIn) and apps; however, this research did not emphasize the use of these forms of communication. The lecturer who implemented the pedagogic model had not use social networks, apps or any online learning management system. Utilizing many new applications of ICT at the same time may mean putting too much pressure on him; therefore, the researcher and the lecturer needed to make a choice on what type of new ICT applications the lecturer used. His university promoted the use of an online learning management system and Therefore, in this research, the lecture's use of LMS was prioritised.

Last, students explore various alternatives of social organisations of learning and languages. ICT actively promotes communication; therefore, it effectively fosters different kinds of social organisations of learning (e.g. working in grounps, working individually and combination). Rich learning resources, including ICT, are also in different languages so students can choose languages which are appropriate for them.

By providing several options of learning resources, instructional organisation, communication, social organisation of learning and languages, ICT seems to facilitate learning effectively. It can be a tool for individuals to create and self-organise knowledge and also a tool for learning via promoting collaboration and interaction.

ICT Is Used as a Tool to Support Learning Individually

ICT, from the cognitive constructivist point of view, is a tool for learners to construct knowledge individually (see *Figure 2.9*). As discussed above, learning from the cognitive constructivist perspective is a process of self-organising knowledge. In this process, learners experience, make assimilation and accommodation, and then gain new equilibrium of cognition. ICT offers rich learning material and resources that can help learner to observe new phenomena and experience in a supportive environment and make sense.

Jonassen, Carr, and Yueh (1998) point out how ICT tools such as search engines, hypermedia and visualisation tools can assist learners construct their knowledge. The authors argue that with the huge volume and the accelerating escalation of information, it is necessary for the learners to have a tool that supports them to access and process information. Search engines such as Google, Bing and Yahoo can help the learners to access and locate the information sources (i.e. websites) which are appropriate for their needs. The websites in general present information in many forms including texts and visual ads (e.g. photos, diagrams, audios and videos). Jonassen et al. (1998) note that the learners internalise more information through their visual modality than other sensory modalities. Therefore, the visual ads such as colours, photos, audios and videos could be considered as useful tools to assist learners construct their own knowledge.

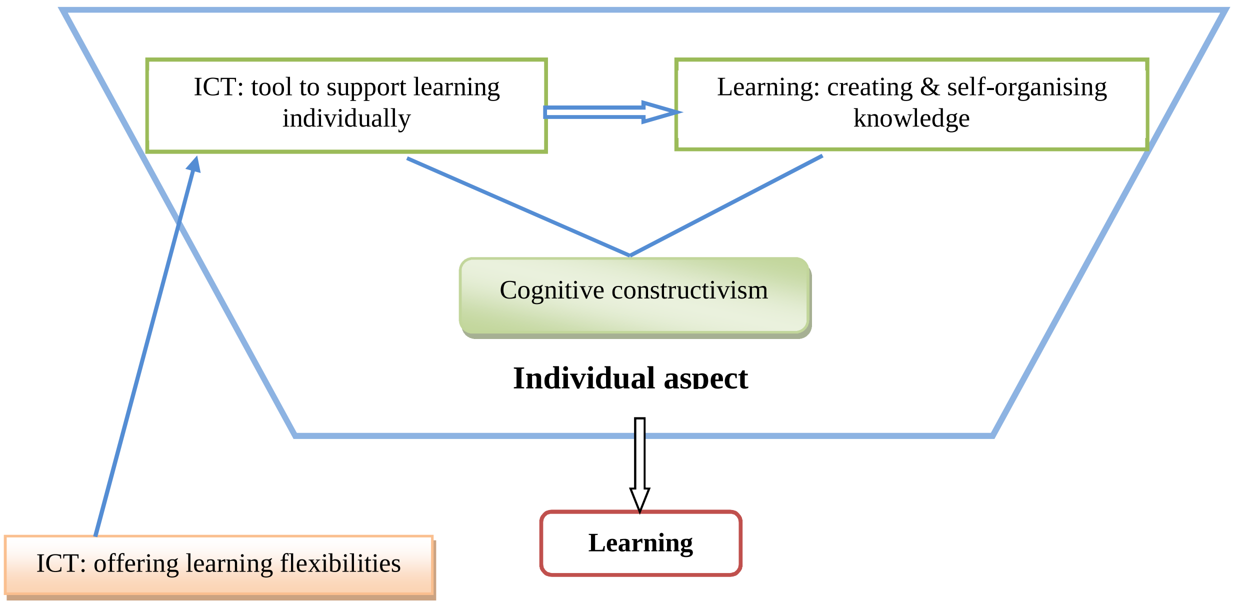


Figure 2.9 ICT supporting the individual aspect of learning

Furthermore, the information in the websites can be organised in linear or hypermedia structures. A link in hypermedia may connect to a full website or a photo, a diagram, texts, an audio or a video file. The link structure enables information to be organised in structured forms which show meaningful relationship between/among groups of information. With the links, learners are able to navigate the information resources, learn the organisation of the information sources and organise/re-organise their own knowledge. Many hypermedia websites allow learners to add and modify the content and the links of the websites. By modifying and creating hypermedia websites and content, learners reflect their understanding of the knowledge and the organisation of the knowledge.

ICT in the light of a constructivist learning principle can also provide students with opportunities to construct their knowledge in symbolic forms (e.g. words, diagrams and photos), and organise the knowledge in a structured system (e.g. mind map, structured folder and database) (Salomon, 1998). Jonassen et al. (1998) interpret that ICT visualisation tools assist learners to reason visually and convey their mental images. For instance, software that is used to draw mind maps (e.g. MINDMAP, SmartDraw and FreeMind) can be an effective tool for students to organise ideas and refine the organisation of the ideas. Drawing software and animation design software are examples of ICT tools support learners representing their mental images.

ICT Promotes Collaboration and Interaction

ICT stimulates interaction by providing a supportive and encouraging communication environment (see *Figure 2.10*). That ICT offers different and convenient ways of interaction has been mentioned above. The interaction will be examined in two contents: interaction with teachers and interaction between learners.

Interaction between teachers and learners plays a crucial role in learning processes. Teachers design curricula, lesson plans, learning materials and learning activities to create a learning environment for students to interact with and to make meaning.

ICT is a powerful tool for teachers to design the interactive learning environment, to facilitate learning by answering questions, mentoring, scaffolding, giving feedback and so on. Learners can interact and get support from educators through different ways, such as face-to-face, email, chat and forum.

The collaboration among learners is also enhanced. ICT provides flexibility in methods of communication. The more flexible communication is, the greater collaboration can be fostered. The application of ICT may provide an interactive learning environment in which students explain and share ideas or hypotheses, justify them, argue or negotiate, and build knowledge.

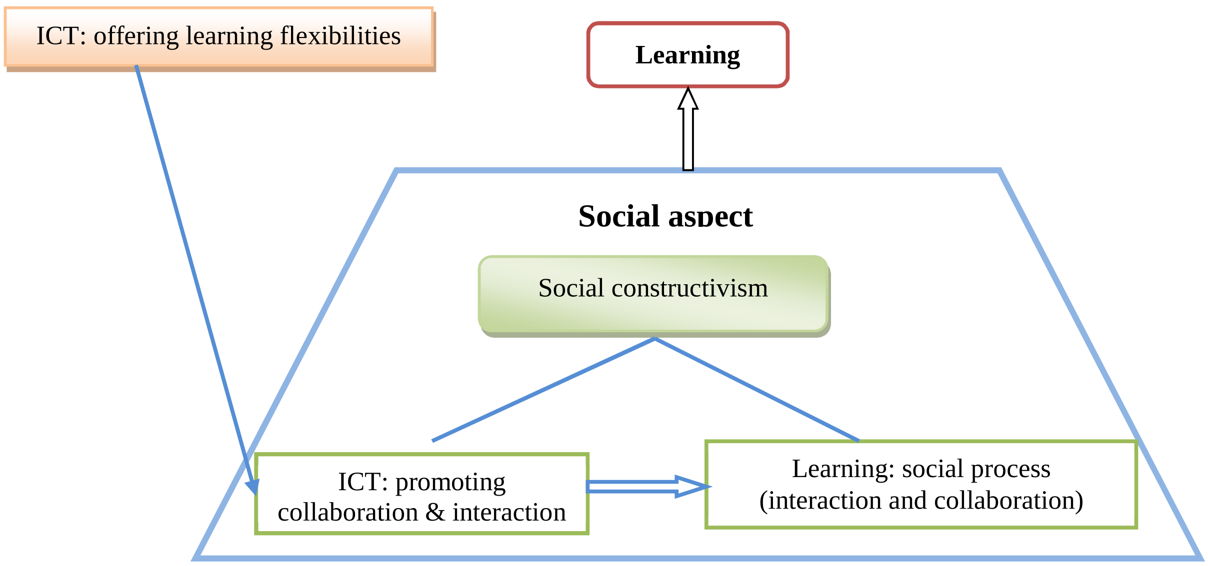


Figure 2.10 ICT supporting the social aspect of learning

In general, learning, including internal re-organising knowledge and constructing understanding in a society, is mediated by tools (e.g. equipment of experiments and ICT). ICT that is considered as a type of mediational means provides learning flexibilities on learning resources, instructional organisation of learning, communication, social organisation of learning and language. By offering the flexibilities, ICT promotes interaction and individuals' learning activities. That

ICT is used as a tool to support individuals learning connects to the cognitive constructivism, while ICT fostering interaction and collaboration relates to the social constructivism.

2.6 Chapter Summary

This chapter described the early phase of the journey to integrate appropriate learning principles with ICT in teaching Physics in the context of Vietnam. Since ICT is a key term in the thesis, the chapter began with defining the term and outlining the history of the use of ICT in education. The scope of ICT in this research was defined as internet, software, multimedia resources, course management systems and computer-based testing systems. The chapter then explained briefly a number of relevant learning theories.

Since constructivist learning theory plays an important role in the Vietnamese context, empirical research on constructivism, ICT and physics teaching and learning was reviewed. The reviewed literature shows that constructivist learning principles and the applications of ICT can provide students with opportunities to enhance their physics learning. For example, the implementation of ICT in education based on constructivist principles results in changing the learners' conceptualisation of Physics (Driver & Scott, 1996), increasing students' performance in Physics (Christina & Dimitrios, 2008), improving collaboration between learners (Wang, 2009) and impacting positively on learners' critical thinking skills (Al-Fadhli & Khalfan, 2009).

Models of integrating ICT in education were also reviewed. The utility of these models were analysed and used for the development of the research model.

Based on the need of the Vietnamese teaching context described in Chapter one and the relevant literature reviewed in this chapter, the first version of the framework '*The Pedagogic Theoretical Model of Integrating Constructivist Learning Principles and ICT*' was developed. The last section of the chapter presented detailed explanations of the model - a product of the first phase of the journey of developing a pedagogic model.

A discussion of the journey is continued in *Chapter four: The Development of the Model.* Experts in science education were invited to evaluate and give feedback on the first version of this model, and based on their comments, together with a further review of literature, the model was revised.

The following chapter will address topics such as methodology, research questions and data collection methods, in addition to the *Research Framework* which will portray the journey of developing this pedagogic model.

Chapter 3 Research Methodology

As mentioned in Chapter 2, the goal of the research was to develop, trial and evaluate a pedagogic model which integrates appropriate learning principles with ICT for the teaching of Physics in the context of Vietnam. Based on the goal of this research and the context, this chapter will examine a range of research paradigms and argue the choice of paradigm for the research. The research design will then be discussed in five sections: research goal & research question, research framework, sample, data collection & data analysis, and timeline.

3.1 Research Methodology

The term “paradigm” was used by Kuhn (1963) in the context of natural science. “A paradigm represents a philosophy or set of beliefs, worldviews, or value used to justify and put forth research priorities and choice” (Cibangu, 2010, p. 177). Each paradigm was established on a certain ontology and epistemology (Scotland, 2012), and then related to specific data collection methods (Table 3.1). Ontological views consist of realism and nominalism. Realists believe that objects exist externally and independently of individuals, while nominalists believe that objects are products of the knower’s awareness (Cohen, Manion, & Morrison, 2011). Epistemology is related to the assumptions about knowledge: it is objective and tangible (objectivism) or it is subjective and personal (subjectivism) (Scotland, 2012).

The positivist paradigm, which is based on realist ontology and objectivist epistemology (Table 3.1), was derived from natural sciences and founded on the belief that objects exist independently of individuals, and knowledge is objective (Cohen et al., 2011). Knowledge and theories in this real world are investigated by experimenting, identifying relationships between variables and testing theories using quantitative instruments (e.g. tests and questionnaires) (Creswell, 2009). A significant aspect of the positivist paradigm is that the results of positivist studies are generalizable and transferable. However, education studies are different from natural science studies. Human beings differ from natural phenomena in that they both are partly determined by and partly determine the external environment. Moreover, Cibangu (2010) states that researchers should also consider the social and cultural context in which the studies were conducted.

Table 3.1 *Research Paradigms*

	Positivist paradigm	Interpretive paradigm
Ontology	Realism: Objects exist externally and independently of individuals	Nominalism: objects are products of knower’s awareness
Epistemology	Objectivism: Knowledge is objective, firm and tangible	Subjectivism: Knowledge is subjective, personal and unique
Data collection methods	Quantitative methods (e.g. questionnaires and tests)	Qualitative methods (e.g. interviews and observation)

(Cohen et al., 2011)

The interpretive paradigm based on nominalist ontology and subjectivist epistemology (Table 3.1) is established on the assumption that objects are products of individuals and knowledge is subjective (Cohen et al., 2011). Interpretive studies provide insight and understanding about the objects or social phenomena by examining the perspectives of insiders in the context of the studies (Rist, 1977). Data collection methods in an interpretive study include but are not limited to interviews, observation and open-ended questionnaires. A weakness of the interpretive paradigm is that researchers have their own social, historical and cultural backgrounds, which may affect their observation, perception and interpretation while they investigate social phenomena (Rex, 1974)

As previously discussed, quantitative data collection methods (e.g. tests and questionnaires) originated from a positivist paradigm and qualitative data collection methods (e.g. interview and observation) can be traced back to an interpretive paradigm; these methods both have advantages and disadvantages. The advantages of quantitative data collection methods include generalisation, transferability and quantitative measuring. However, the quantitative methods do not capture the insight and understanding of participants' behaviour in a sociocultural context. Researchers' decisions on the use of quantitative, qualitative or both approaches for data collection methods depend on research goals and research questions.

The goal of the research was to develop, trial and evaluate a pedagogic model which integrates appropriate learning principles with ICT for the teaching of Physics in the context of Vietnam. Depending on the phases of the research and the objectives of each phase, a quantitative, qualitative or mix of data collection methods were employed.

During the model development phase, the researcher needed to make decisions about what pedagogic model to adopt for the Vietnamese context. Insight and understanding about the literature of the field was essential in developing a suitable pedagogic model. Moreover, collecting and analysing experts' evaluations of the chosen model were necessary to ensure the model was appropriate for Vietnamese physics teaching. The qualitative data collection methods used by the researcher in seeking feedback from experts were fundamental in making decisions on the pedagogic theories to adopt for the Vietnamese context.

The model was first developed and then implemented. In the second phase, the pedagogic model was implemented in classrooms in one semester (16 weeks) at a university in Vietnam; and the impacts of the model were examined. Both quantitative and qualitative methods were employed in order to (1) measure the improvement in physics performance and thinking skills by comparing the test results at the beginning and the end of the semester and (2) to investigate how the model impacted on students' learning process during the semester.

Pre and post-tests related to students' knowledge and skills were conducted during one semester, the results indicating the impact of the model. The quantitative data collection methods helped to examine whether the use of the model enhanced students learning and whether their knowledge as well as their skills improved.

As mentioned above, an advantage of quantitative methods is that the improvement in students' knowledge and skills could be measured and so quantified. However, with the use of quantitative methods only, the learning processes of students during the semester would not have been investigated. For this reason, qualitative methods were also used to investigate the influence of the model on students' learning processes during the semester, with consideration of the students' social context, and the passive and active roles they assumed in their learning processes.

In conclusion, this research utilised quantitative and qualitative data collection methods of tests (pre and post-tests in optics and critical thinking skills), questionnaires and unstructured interviews. The quantitative data collection methods were useful in measuring how the pedagogic model influenced students' knowledge and skills. To obtain an insight into the role students played in their learning processes, qualitative data collection methods were utilised. Furthermore, the combination of these two data collection approaches (qualitative and quantitative) helped enrich the data, triangulate it and maximise reliability and validity (Cohen et al., 2011; Mertens, 2010; Teddlie & Tashakkori, 2009). Complementary data and data triangulation will be discussed in Chapter 5.

3.2 Research Goal & Research Question

3.2.1 Research Goal

The goal of the research was to develop, trial and evaluate a pedagogic model which integrates appropriate learning principles with ICT for the teaching of Physics in the context of Vietnam.

3.2.2 Research Question

The research questions are:

1. In what ways does the application of the pedagogic model increase interaction within the learning environment?

2. Does the application of the pedagogic model improve students' physics test results?

3. In what ways does the application of the pedagogic model enhance students' critical thinking skills?

3.3 Research Framework

The research examines the impact of the CSI Model on students' performance in Physics, interaction within the learning environment and critical thinking skills. This model is implemented in a university context, and quasi-experiment is the prevalent research style (Cohen et al., 2011; Muijs, 2004; Walliman, 2006). The research framework (*Figure 3.1*) presents an overview of this research that was conducted in two phases: the Model Development and the Model Implementation.

3.3.1 Phase 1: The Model Development

This phase started with a literature review and context analysis, which is detailed in Chapter 2 and Chapter 4. Current literature and research on constructivism, sociocultural theories, ICT, physics learning and teaching were reviewed. The context of Vietnam was also described. Based on the literature review and context analysis, a pedagogical model was developed. Experts in science education were invited to examine the pedagogical model. The objectives of the expert-evaluation were to (1) determine to what extent the model is suitable for teaching and learning, and (2) improve the model.

Two New Zealand experts and a Vietnamese expert evaluated and gave feedback on the model. The New Zealand experts were renowned in science education and have significant expertise in the teaching and learning of science, and integrating ICT in teaching. The Vietnamese expert was an experienced Physics senior lecturer. He was also a vice-head of the School of Education at a university in Vietnam. The aim of inviting the experts from different backgrounds to evaluate the model (as a form of investigator triangulation) was to ensure the validity of the model, and the consequent trustworthiness of the findings. The model and the evaluation form (Appendix 1) were sent to the experts. They noted the strengths of the model and suggested some changes in order to improve the pedagogic model. Based on the experts' suggestions, several revisions were made. The revised pedagogic model was named the CSI Model (The Pedagogic Model of Integrating **C**onstructivist and **S**ociocultural Learning Principles with **I**CT).

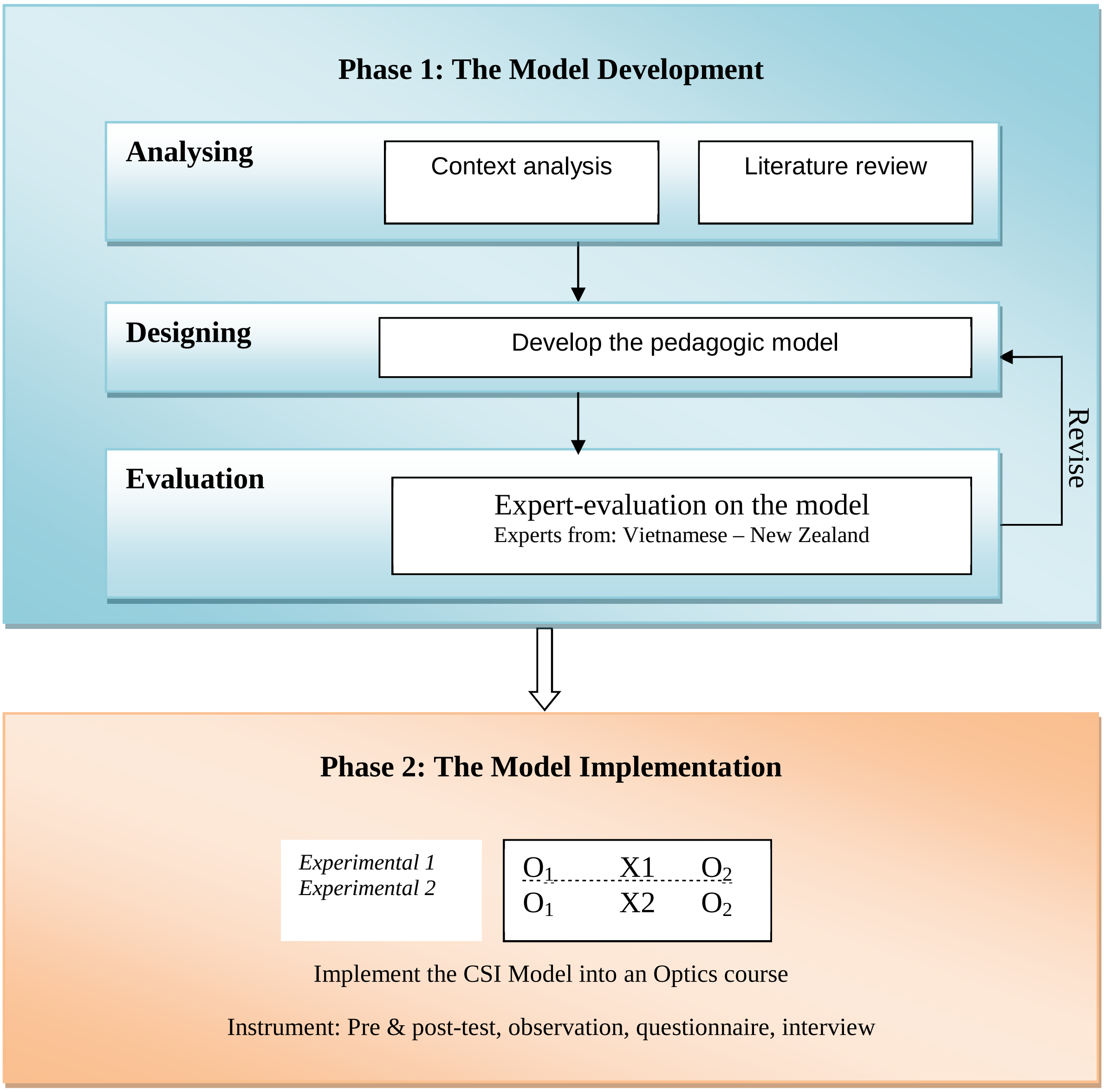


Figure 3.1 Research framework

3.3.2 Phase 2: The Model Implementation

The next phase of this research was the implementation of the model, which is described in detail below. As mentioned above, this research employed a quasi-experimental design that could be presented as:

O_1	X1	O_2
O_1	X2	O_2

The symbols were derived from Campbell & Stanley (1963) where:

- O_1: Pre-tests which are the same for both groups
- O_2: Post-tests which are the same for both groups
- X_1: Exposure of group one (The Morning Group) to the application of the CSI Model and an online learning management system
- X_2: Exposure of group two (The Afternoon Group) to the application of the CSI Model (without an online learning management system)
- -------------------- : the two groups are not randomly allocated

This design has been incorporated into the overall research framework in *Figure 3.1*.

The CSI Model was implemented by a lecturer in an optics course of a physics department within a school of education of a university in Vietnam. The process of finding and inviting a lecturer to be involved in this research included: (1) administering questionnaires to lecturers of the physics department, interviewing nine students and four lecturers (who were most likely to use ICT in their teaching in this department), (2) identifying lecturers who usually use ICT in teaching and their willingness to implement a new pedagogical framework into their teaching practice, and (3) inviting a lecturer to implement the CSI Model. The purposes of interviewing both students and lecturers were to get the students' voice on lecturers' use of ICT and to triangulate the data of teachers' interviews by students' interviews.

The lecturer participating in this research had applied some ICT in his teaching, and had required students to use ICT to make PowerPoint presentations for optics topics in the past. Because the objective of the research is to investigate impacts of the CSI Model on physics learning, it was appropriate to invite a lecturer who had utilised ICT in education so that the lecturer can fully concentrate on implementing the model rather than becoming familiar with applying ICT in teaching practice.

The course was delivered over 16 weeks, one semester, including one week for orientation and one week for the examination. There were two groups of students involved in the research: a Morning Group and an Afternoon Group; most of the students were in the second year of their university programmes. These students were not allocated randomly into the two groups; they enrolled in the groups based on their study timetables. This allocation might result in the differences in Optics knowledge and thinking skills of the two groups; however, the differences could be identified by the pre-test on Optics and thinking skills. The CSI Model was implemented in both groups; however, there was one difference in the application: the Morning Group used an online learning management system for Optics study while the Afternoon Group did not.

Both quantitative and qualitative methods were employed in this research. The four types of data collection instruments were tests, observation schemes, questionnaires and interviews to collect and triangulate the data. Tests consisted of a pre-test and a post-test on optics and critical thinking skills; The students' interactions were observed; The students were administered questionnaires at the beginning and the end of the semester; and two interviews with lecturers, and five students' focus group interviews were performed.

T-test and Cohen's d were used to analyse data for the tests, observation schemes and some parts of questionnaires while descriptive statistics and graphs were used for most questions of the questionnaires (Cohen et al., 2011; Muijs, 2004; Walliman, 2006). The interviews were coded, and the codes were categorised into nodes (Cohen et al., 2011). Finally, the conclusion was developed and the research questions were discussed. An overview of the data collection method, the analysis and the research questions is provided in Table 3.2.

3.4 A Discussion of Ethical Considerations

The current research followed the ethical guidelines of the University of Waikato. Before the research was conducted, an ethics proposal which included different aspects of ethics considerations was applied to and approved by an ethics committee of the university (Appendix 6).

Letters were sent to participants to invite them to participate in this research (Appendix 6). The letters explained the research and noted that:

- their participation was voluntary,
- they had the right to decline to be involved in this research,
- they had the right to withdraw from the research and have their data deleted.

The data which was collected from participants are kept confidential. The data is reported anonymously and used only for writing the dissertation, presentations and publications.

3.5 Research Participants

Ninety three students in four-year-degree programmes of a physics department at a school of education of a university in the south of Vietnam participated in this research. The students were training to be teachers at upper-secondary schools. Most of them were in the second year (87.6%), though some were either in their first year (7.8%) or in their third year (5.6%). Of the students, 70% were female. In Vietnam, students normally finish upper-secondary schools at the age of 18 and enter universities at 19. The average age involved in the research was 20.2 years old with 64% being 20 years old (*Figure 3.2*).

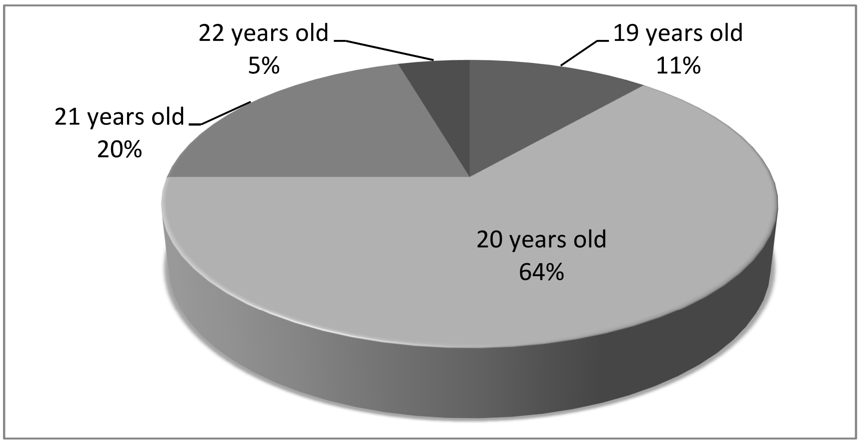


Figure 3.2 Students' ages

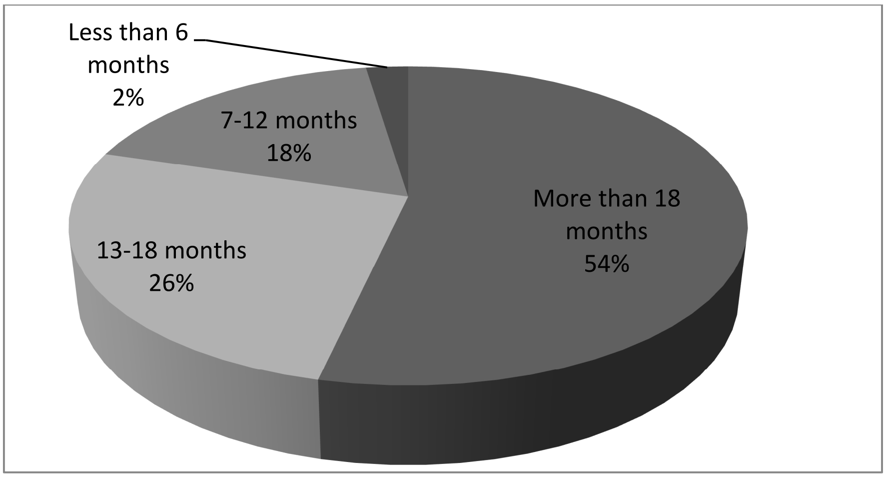


Figure 3.3 Duration of experience in using computers

The majority of the students had been using computers for more than 18 months (*Figure 3.3*). More than a half of them owned a computer (53%), and one-third (34%) were able to connect to the Internet at home. The students used computers and the internet quite regularly; 92% stated that they accessed the internet from every week to every day, and it was the same percentage and frequencies for using computers.

The students registered for the Morning or Afternoon Group based on their timetables; thus, the groups were not divided randomly. The Morning Group contained 53 students (68% female, average age 20.2) while the Afternoon Group had 40 students (74% female, average age 20.2). Both groups implemented the CSI Model, but only the Morning Group used a learning management system (LMS) in the Optics Course.

3.6 Data Collection Methods and Data Analysis

The data collection and analysis methods are presented in Table 3.2. In the first phase of the research – *the Development of the CSI Model*, the main source of data was experts' evaluation and feedback on the model. Emails were sent to experts to invite them to participate in the research. When the experts agreed to give feedback on the model, an evaluation form and the first version of the model with explanations were then sent to them via emails (Appendix 1). The evaluation form included contact information of the experts, objectives of expert-evaluation and some aspects that should be considered for evaluating and giving feedback. These aspects were:

- whether the model is able to reflect the nature of students' learning;
- what the strong points and weaknesses of the model are as a pedagogic theoretical framework supporting teaching physics;
- which part of the model should be improved so that it will support for teaching physics effectively; and how the model should be revised.

The experts evaluated the model and sent their feedback to the researcher by email, which was then used to improve the model.

Data collection methods in the second phase of the research – *the Implementation of the Model* included tests, questionnaires, interviews and observations. Table 3.2 shows research questions and data collection methods related to the questions. Data to help answer each research question was obtained from at least two sources of data by a qualitative method and quantitative methods. The purposes of collecting data from different sources by different methods were to help triangulate and enrich the data. The following sections will explain in detail the data collection methods that were used in the second phase of the research. Data analysis methods will also be presented.

Table 3.2 *Data Collecting and Analysing Methods Address Research Questions*

Research Phases	Research questions	Data collecting and analysing methods
1. The Development of the CSI Model		Online evaluation
2. The Implementation of the CSI Model	1. In what ways does the application of the pedagogic model increase interaction within the learning environment?	Observation scheme (to evaluate the degree of interaction): t-test, Cohen's d Questionnaire: descriptive statistics, graph, t-test Interview
	2. Does the application of the pedagogic model improve students' physics test results?	Optics test: t-test, Cohen's d Interview
	3. In what ways does the application of the pedagogic model enhance students' critical thinking skills?	CCTST: t-test, Cohen's d Questionnaire: descriptive statistics and graph Interview

3.6.1 Test and Observations

3.6.1.1 California Critical Thinking Skill Test (CCTST)

CCTST was developed based on the results of the Delphi Project which was mentioned in Chapter one. The test is now a commercially produced and standardised test from Insight Assessment (http://www.insightassessment.com/). It is widely used to evaluate learners' critical thinking skills at universities and colleges in many countries (Facione, Facione, & Winterhalter, 2011; Wheeler & Collins, 2003; Yang, 2008; Zhou, Wang, & Yao, 2007). CCTST was available in more than 20 languages, but not Vietnamese. Due to the work of this researcher, a Vietnamese version was developed and became an authorised translation (Facione et al., 2011; Insight Assessment, 2011). The process of translating the test contained six stages:

1. Translation of the test into Vietnamese.
2. The Vietnamese translation of the test was reviewed by three Vietnamese lecturers.
3. Independent translation of the Vietnamese version back into English.
4. Revisions to the Vietnamese version of the test requested by Insight Assessment.
5. Revision of the Vietnamese version.
6. Approval by Insight Assessment of the final version.

The test containing 34 multiple choice questions assesses critical thinking skills that are measured through the scores of five individual scales: analysis & interpretation, inference, evaluation & explanation, inductive reasoning and deductive reasoning. The reliability and validity of the test were ensured and outlined in the test manual.

Reliability

According to Streiner (2003), in a test the score of a student should reflect a true score; however, the total score normally includes the true score and errors related to measurement. Therefore:

$$score_{total} = score_{true} + score_{error}$$

In a simple way, reliability can be considered as the ratio of the variance of the true scores and total scores:

$$Reliability = \frac{\sigma_{true}^2}{\sigma_{total}^2}$$

where σ_{true}^2 is variance of true scores, and $\sigma_{total}^2$is the variance of total scores. This equation is used in cases where a group of people with different characteristics is measured. If the group has the same characteristics which need to be measured, their true score would be the same. As a result, $\sigma_{\mathrm{true}}^2 = 0$, and the equation becomes meaningless.

Internal consistency reliability is also an important measure, and reflects how well test items measure the same construct producing similar results (Cohen et al., 2011; Muijs, 2004). It was originally calculated by the split-half method (Cronbach & Shavelson, 2004; Streiner, 2003). Based on the idea of computing the mean of all probable split half reliabilities, Kuder and Richardson (1937) developed a more accurate formula calculating internal consistency reliability for dichotomous variables: the Kuder-Richardson Formula 20 (KR20)

$$KR20 = \frac{k}{k-1}\left[\!\left[1 - \frac{\sum p_k q_k}{\sigma_{total}^2}\right]\!\right]$$

where k is the number of items, $p_k$the number of correct answers per total number of answers, $q_k$the number of incorrect answers per total number of answers.

Cronbach (1951) developed KR20 into the formula:

$$\alpha = \frac{k}{k-1}\left[\!\left[1 - \frac{\sum \sigma_k^2}{\sigma_{total}^2}\right]\!\right]$$

where σ is standard deviation, σ_{total}^2 the variance of total scores, σ_k the standard deviation of an item and $\sum \sigma_k^2$ the sum of variances of all items.

Alpha(α) is the general formula of the Kuder-Richardson Formula 20 which is only applied for dichotomous (binary) variables (Cliff, 1984; Cronbach & Shavelson, 2004; Streiner, 2003).

Both internal consistency reliabilities, Cronbach's Alpha and KR20 range from 0 to 1 (Cortina, 1993; Cronbach & Shavelson, 2004). These coefficient are equal to or large than 0.7 means that the tests are considered reliable (Cohen et al., 2011; Facione et al., 2011; Muijs, 2004). In the CCTST, KR20 was calculated. It varied from 0.78 to 0.82 (Facione et al., 2011) (reliable).

Validity

The validity of a test is the extent to which a test can measure what it purports to measure (Ary, Jacobs, & Sorensen, 2010). In a standardised test, three kinds of validity are usually considered: content validity, construct validity and criterion validity. Content validity reflects if a test covers the abilities or domain of content which is being measured (McGoey, Cowan, Rumrill, & LaVogue, 2010). Construct validity indicates to what extent a test can measure the abstract construct through observable variables (Jha, 2008). Criterion validity presents the precision of a test by comparing it with external criterion (Cohen et al., 2011).

The three kinds of validity of the CCTST were ensured by the research group at Insight Assessment (Facione et al., 2011). *Content validity* was addressed by designing the test items based on definitions and descriptions of critical thinking skills and sub-skills from research of the America Philosophical Association (Facione, 1990a). *Construct validity* was reassured by considering many aspects such as excluding social class and sex-role contexts, reviewing by independent researchers, and proving the increase of learners' CCTST scores after attending critical thinking courses and training programmes. There are two types of *criterion validity*: predictive validity and concurrent validity (Muijs, 2004). Predictive validity is defined if the test can predict theoretical expected outcomes; the CCTST scores significantly positively correlate with predicted graduate performance (Giddens & Gloeckner, 2005; McCall, MacLaughlin, Fike, & Ruiz, 2007; Williams et al., 2003). Concurrent validity refers to what extent the test agrees with other tests (Cohen et al., 2011); CCTST scores strongly correlate with the scores of other critical thinking and higher order reasoning tests (e.g. GRE total score: $r = 0.719$, $p<0.001$ and GRE analytic: $r = 0.708$, $p<0.001$) (Facione et al., 2011). The staged process of translating the test into Vietnamese is also pertinent to the validity of Vietnamese version of the test.

3.6.1.2 Optics Test

The optics test is a norm-referenced lecturer-developed test that is used each semester when this class is taught. The test was designed by the optics lecturer based on the course outline in order to (1) evaluate students’ optics knowledge and understanding, and (2) compare a students’ performance before attending the optics course with the performance after attending the course. There are 40 multiple choice items in the test which cover the domain of Optics content provided in the course (Table 3.3). The same optics test paper was used for the pre-test and post-test. The pre-test was carried out on the first week of the semester, the post-test on the fourteenth week.

Table 3.3 *Optics Test Blueprint*

Optics Content	Test Item Number
Black body	Question 6, 24
Concave mirror	Question 27
Continuous spectrum	Question 8
Convex lens	Question 10, 12, 15
Diffraction	Question 3, 22, 25, 34, 38
Hand lens (magnifying glass)	Question 17, 32
Hydrogen emission spectrum lines	Question 14
Methods of measuring the speed of light	Question 37
Microscope	Question 16
Nature of electromagnetic waves	Question 7
Optical interference	Question 4, 5, 9, 13, 19, 20
Photoelectron effect	Question 18, 21, 25
Polarisation, Polarised light, Polariser	Question 23, 29, 33, 35
Prism	Question 2, 28
Quantum optical formulas	Question 30
Reflection and refraction	Question 11
Telescope	Question 1,
Telescope Celestron of the Physics Department (CTU)	Question 40
Unit if illuminance (Lux)	Question 36
Unit of luminous intensity (Cd – Candela)	Question 39
Wave length of light and temperature of objects	Question 31

3.6.1.3 In-class Observations and the Observation Scheme

The observations were conducted of the two groups in weeks 2, 3, and 13. In each week, six hours were observed (3 hours of the morning group and 3 hours for the afternoon group). The frequency of observation was 4 times/lecture (at the 10^{th}-15^{th}minute, the 20^{th}-25^{th} minute, the 30^{th}-35^{th}minute and the 40^{th}-45^{th}minute). The observation length was six minutes, and the incident time interval was 60 seconds (*Figure 3.4*). In each group, there were 12 observations per week and three weeks in the semester, making a total of about 36 observations (*Figure 3.5*).

Two observers were invited and trained to use the observation scheme and score the interaction degree. The observers were lecturers at the university. They were provided with detailed explanations on the scheme and how to score the degree of interaction in the scale of ten by the researcher. Then they went to the optics classes in week two to practice observing and scoring the interaction degree. Right after the-week-two observations when their memory and impression about what happened in the classes were still fresh, the two observers and the researcher had a meeting. The observers compared the scores and discussed with each other on the differences between their scores for interaction degree at certain points of time. The discussion would help each observer explain why one decided the scores, and seek for opportunities that they could agree on the same scores for the same points of time. Although the two observers had experience on conducting education research, the process of explaining how to work on the scheme, practicing in week two and having discussion between them on the scores were important for the assurance of the observation reliability.

Two trained observers worked at the same time in order to provide investigator triangulation. They scored the degree of interaction (from 0 to 10) and wrote their comments on the observation scheme (*Figure 3.4* and Appendix 2). Observations in a period were considered and included in the findings of the research if the inter-rater reliability was above or equal to 0.90. The inter-rater reliability of each record was computed as:

$$\frac{number\ of\ times\ two\ observers\ agree}{number\ of\ possible\ oppotunities\ to\ agree}\ x\ 100\%$$ (Cohen et al., 2011)

The average of the two observers' scores was used for data analysis. For example, there was an instance that the observer one scored 5 for the degree of interaction between teacher-students while the observer two scored 6. The score used for data analysis was calculated by:

$$\frac{5+6}{2} = 5.5$$

The average scores were computed by MS Excel and then copied to SPSS (Figure 3.6 and Appendix 7) for t-test analysis.

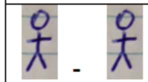
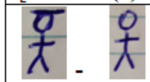
The Observation Scheme **Week ……..** **Group …….**

For Recording Interaction within Learning Environment

Date: …………………. Time: ……………… Location …………. Period No.: ………….

Observer's name: ……………………………………

Observation 1: minute 10th-15th

Timeline / Interaction between	1st 60s	2nd 60s	3rd 60s	4th 60s	5th 60s	6th 60s	Note
 [student(s) – student (s)]							
 [teacher – student (s)]							
 [student(s) – learning material(s)]							
Task							
Task in hand							
Previous task							
Future task							
Non-task							

The degree of interaction: Scale of 10

	10	9	8	7	6	5	4	3	2	1	0	
Very highly interactive	_	_	_	_	_	_	_	_	_	_	_	Not interactive at all

Figure 3.4 A sheet of the observation scheme

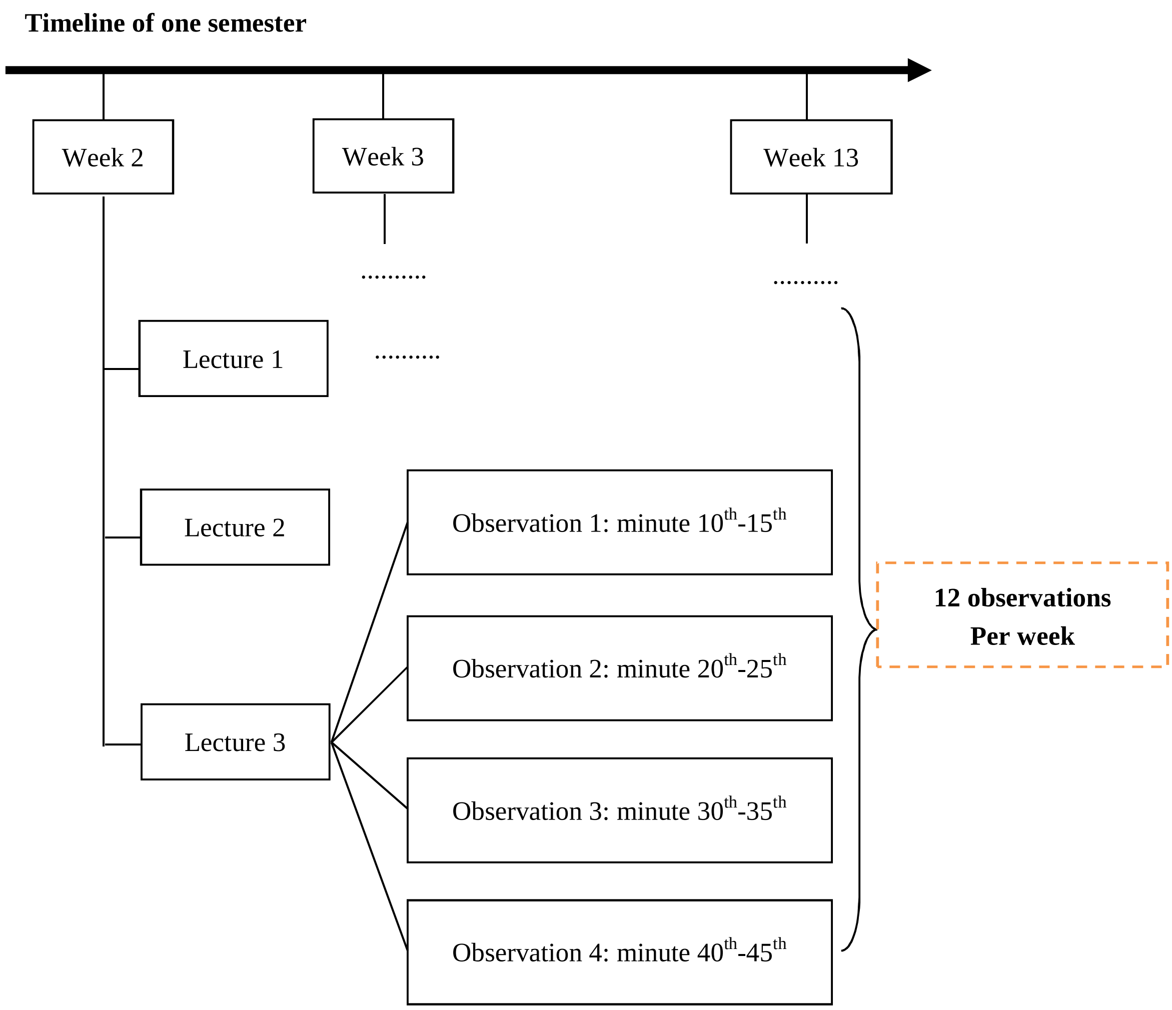
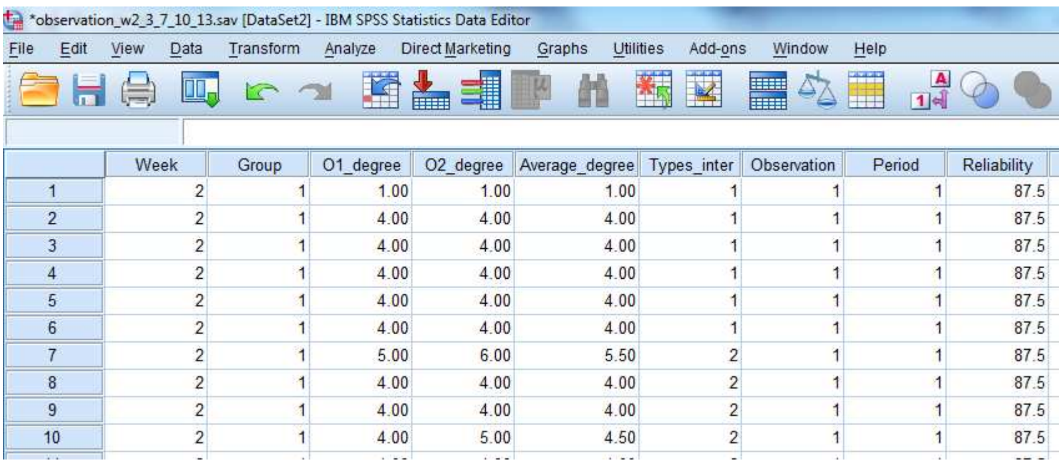


Figure 3.5 Observation timeline



	Week	Group	O1_degree	O2_degree	Average_degree	Types_inter	Observation	Period	Reliability
1	2	1	1.00	1.00	1.00	1	1	1	87.5
2	2	1	4.00	4.00	4.00	1	1	1	87.5
3	2	1	4.00	4.00	4.00	1	1	1	87.5
4	2	1	4.00	4.00	4.00	1	1	1	87.5
5	2	1	4.00	4.00	4.00	1	1	1	87.5
6	2	1	4.00	4.00	4.00	1	1	1	87.5
7	2	1	5.00	6.00	5.50	2	1	1	87.5
8	2	1	4.00	4.00	4.00	2	1	1	87.5
9	2	1	4.00	4.00	4.00	2	1	1	87.5
10	2	1	4.00	5.00	4.50	2	1	1	87.5

Figure 3.6 Observation data in SPSS

3.6.1.4 Data analysis

SPSS (Statistical Package for Social Science) was utilised for quantitative data analysis. For the tests, a t-test was computed to examine if there were significant differences between tests' scores. The differences are statistically significant when significance level, the probability value (p value), is below 0.5 ($p<0.05$). To determine the extent of the difference between tests' scores, Cohen's d was used, where the difference is considered strong if Cohen's d is larger than 1 (Cohen, Manion, & Morrison, 2007).

$$Cohen's\ d = \frac{Mean\ difference}{Pooled\ standard\ deviation}$$

$$Pooled\ standard\ deviation = \frac{(SD\ group\ 1 + SD\ group\ 2)}{2}$$

Effect size strength:

0.00 – 0.20: weak

0.21 – 0.50: modest

0.51 – 1.00: moderate

>1.00: strong

3.6.2 Questionnaires

Two similar questionnaires were administered to the students at the beginning and at the end of the semester (Appendix 3). The questionnaires sought students' information on their background, interaction occurring inside and outside class, and the self-assessed improvement of their thinking skills after attending the

Optics Course. In this research, some students did not respond to all the items of the questionnaires.

3.6.2.1 Questionnaire Administered at the Beginning of the Semester (Pre-questionnaire)

The questionnaire delivered to the students at the beginning of the semester included three sections: Section A - background information, Section B - learning activities inside and outside the classes, and Section C - students' expectations of the course. The *Background information* section (Section A) included 9 questions seeking general information about students (e.g. gender, year of enrolment, how long the student has been using computers and how often he/she uses computer and the internet). Most of the questions were multiple-choice.

The *Learning activities inside and outside class* section (Section B) had 12 multiple choice questions investigating students' interaction in the courses which had been provided in the previous semester (Semester I). The questions asked the students to evaluate how often learning activities occurred inside and outside the classes in the previous semester. Examples of these learning activities comprised presenting ideas, asking questions, contributing to discussions and working on projects with classmates. Eight out of the ten questions were adapted from a questionnaire of National Survey of Student Engagement (2010). Among the twelve questions, seven of them focused on interaction inside class; and the others focused on interaction occurred outside class.

Section C included one open ended question where the students could write their expectations of teaching and learning activities in the course. The questionnaire ended with thanking to students for spending their time to answer the questions.

3.6.2.2 Questionnaire Administered at the End of the Semester (Post-questionnaire)

The questionnaire delivered to the students at the end of the semester included four sections. Section A (background information) had the same content with the questionnaire administered to the students at the beginning of the semester. The questions in Section B (learning activities inside and outside the classes) of the post-questionnaire were similar to those of the pre-questionnaire. However, these post-questions focused on students' evaluation on how often the learning activities occurred in the Optics Course of the current semester when the research was conducted (semester II). The difference between Section B of the pre-questionnaire and the post questionnaire was:

- In the pre-questionnaire, Section B inquired into interactions in other courses provided in semester I (the previous semester).
- In the post-questionnaire, Section B focused on students' interactions in the Optics Course in semester II (the current semester).

The *Thinking skills* section (Section C) had seven Likert scale questions about the extent to which students felt their thinking skills improved during the optics course. The thinking skills mentioned on the questionnaire included interpretation, analysis, evaluation, inference, explanation, inductive reasoning and deductive reasoning. The Five Likert scales used in this section included *exceedingly*, *very much*, *somewhat*, *a little bit* and *not at all*.

3.6.2.3 Data analysis

SPSS was employed to analyse the data from the questionnaires. Data from Section A of both questionnaires was students' background information. Thus, descriptive statistics such as frequencies, percentages and graphs were utilized. The result from the descriptive statistics was used to describe the sample of this research in Section 3.5.

Descriptive statistics (e.g. frequencies, percentages and graphs) on the Section B data of the post-questionnaire was computed. The descriptive statistics illustrated students' reflections on interactions within the Optics Course learning environment. Furthermore, comparisons on the frequencies of activities reflecting interactions (Section B of the two questionnaires) occurring in the Optics Course – semester II and in the other courses – semester I were conducted. The purpose of the comparisons was to identify the differences in interaction degree of the Optics Course and other courses in the previous semester if there was any.

Data from the *Thinking skills* section (Section C of the post-questionnaire) reflected students' self-evaluation of their improvement on seven critical thinking skills. In order to help describe students' self-evaluation, frequencies and percentages were calculated; and graphs were constructed.

3.6.3 Interview

Unstructured interviews in Vietnamese with the lecturer and a tutor were conducted in the middle of the semester. The lecturer was interviewed at the end of week four of the semester. The interview focused on the lecturer's reflection on three aspects: the students' learning, the differences between teaching strategies of the lecturer last year and this year, and the effectiveness of the CSI Model. A shorter interview with the tutor which aimed at his reflection on students' learning was also conducted in week five.

At the end of the semester, a structured interview with the lecturer was performed. The interview contained questions which focused on the following content:

- Reflection on the implementation of the CSI model into the Optics Course on the aspects of teaching strategy, assessments, learning materials, instructional organisation and interaction.
- Reflection on the CSI model on the usefulness of the model for teaching and students' learning, the appropriateness of the model in the context of his university in specific and Vietnam in general, the strong points and the points needed to be improved.
- Whether the model encouraged the class to be more interactive.
- Whether students' learning was enhanced and how.
- Other comments on the CSI model.

Un-structured interviews, in Vietnamese, were carried out with groups of students in week seven (one interview), week fourteen (two interviews) and week fifteen (two interviews). Student focus group interviews were employed in this case in order to encourage students to engage in a rich discussion about the topic/question in groups. In this way, diversified perspectives on a topic/question might be presented and discussed deeply among students during the interviews. One of the disadvantages of focus group interviews was that it was hard to control. While some students dominated the discussions, others did not talk much. Interviewers needed to encourage the students who did not have chance to present their ideas by directing questions to them. The students voluntarily participated in the interviews, and each student participated in only one interview. The number of students in each group was from four to ten (Table 3.4). The goal of the students' interviews was to record students' reflections on the implementation on the model:

- What the students think about the way that the Optics Course was taught.
- Whether this teaching model is suitable for them.
- Comparing this Optics Course and other courses.
- The role of ICT in their learning process.
- The strong points and weaknesses of the course

Table 3.4 *Students Focus Group Interviews*

Interview No.	**Date**	**Number of students**
1	Week 7: 03 March 2012	4 students (Morning Group)
2	Week 14: 21 April 2012	9 students (Morning Group)
3	Week 14: 21 April 2012	10 students (Afternoon Group)
4	Week 15: 28 April 2012	6 students (Morning Group)
5	Week 15: 28 April 2012	7 students (Afternoon Group)

Data Analysis

NVivo software, which supports qualitative data analysis, was used to analyse the interview data. In order to be analysed, the data were initially imported into NVivo. *Figure 3.7* demonstrates the five files of student interviews imported into NVivo under the folder '*Student interview*'. The interview data from the lecturer and the teaching assistant was also imported into the software under the folder ‘*Lecture_tutor interview*’ (*Figure 3.8*).

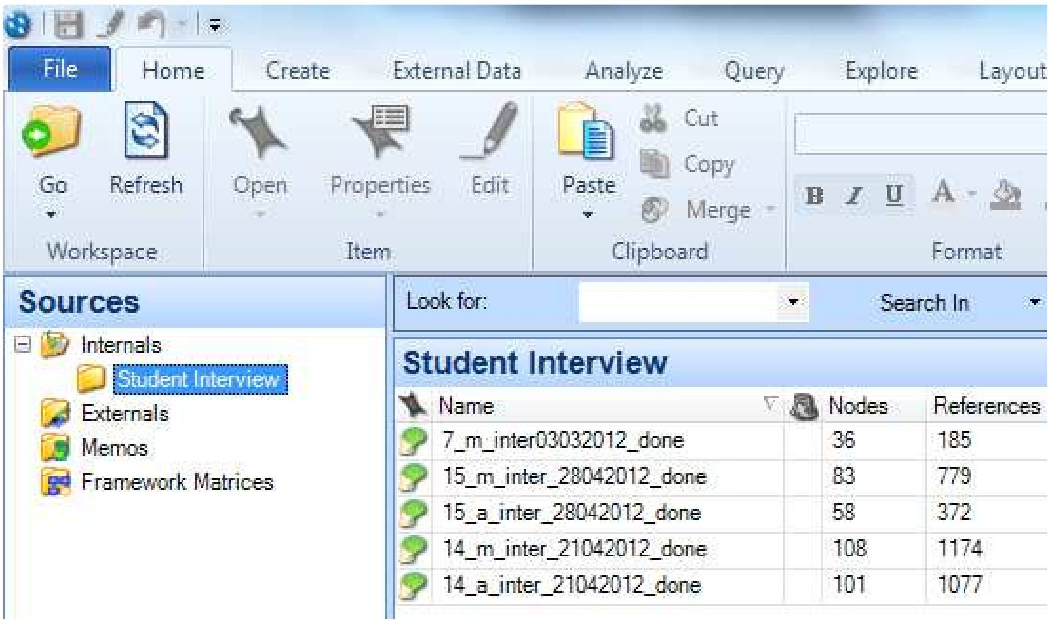


Figure 3.7 Importing data from interviews with students to NVivo

Each interview was divided into small segments comprising one or more sentences which illustrated a meaningful topic. These segments were called references in NVivo. A segment was then coded into free node/s (open codes) which reflected the content of the segment (Cohen et al., 2011; Marshall & Rossman, 1995). The creation of the free nodes was based on the content of the interview. The research questions and the theoretical framework helped the researcher understand the nature of the interview data; however, at this stage, they had not been used as a guide for coding these free nodes.

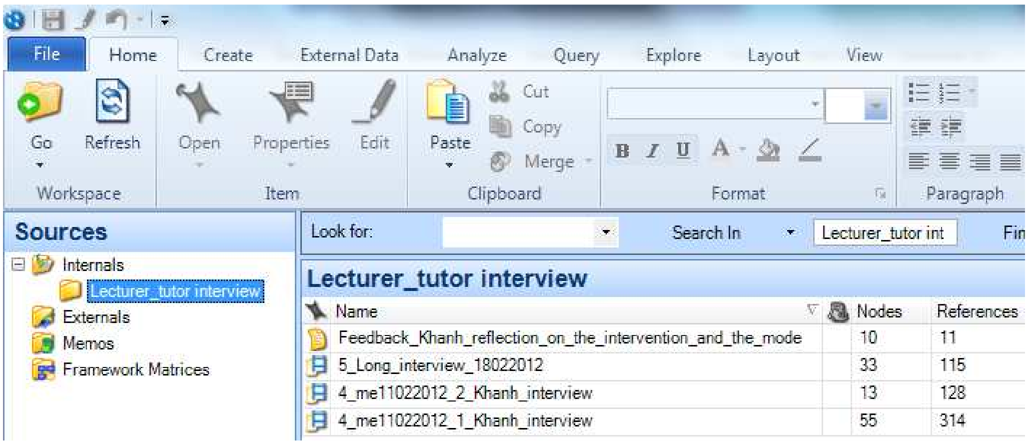


Figure 3.8 Importing data from interviews with the lecturer and teaching assistant to NVivo

At the beginning of this coding process, a block of text was coded independently by two researchers. The codes (nodes) were then compared, and a discussion between the two researchers was generated in order to improve the coding process.

Table 3.5 shows an example of texts from students' interviews coded into free nodes. The two example free nodes '*Reading learning material*' and '*Study is more fun*' presented in the left column of the table were coded from segments of the interviews with students. Transcripts of some of the segments related to the nodes are illustrated in the right column. Similar to Table 3.5, Table 3.6 presents an example of transcripts of some segments of interviews with the lecturer and the teaching assistant interviews coded into free nodes.

Table 3.5 *An Example of Texts from Students' Interviews Coded into Free Nodes*

Free Nodes	Quotes
Reading learning material	"I believe that we prepare for the lesson at home as we did. We read in advance. We then go to classes, the teacher explains to us. It is easier for us to understand [the lesson] and remember it than when we go to classes with a blank head." – Week 14, Afternoon Group "If we go to class without reading at home in advance, the teacher lectures; it is hard for us to understand and to remember." – Week 14, Afternoon Group "When we read [learning materials] at home, we know which parts we understand, which parts we don't. In classes, we concentrate to listen to the parts we don't understand. For the parts we understand, we can ignore them." – Week 14, Afternoon Group "If we don't read [learning materials] at home in advance, we listen to the lecturer steadily. This is not that good [as reading in advance]". – Week 14, Afternoon Group "[I] go to a physics web page, read and research the content. [I] read and find something related to lecture notes. Something the lecture notes do not explain clearly, [I] look for it and read it" – Week 14, Afternoon Group "Going to webpages, I saw that they had whole text books. I read and looked for important ideas" – Week 14, Afternoon Group "To prepare for a presentation, it required hard working. We need to read learning material carefully" – Week 14, Morning Group "One of the strong points [of the teaching methods in the Optics Course] is that we need to read the learning materials in advance, before coming to class. For other courses, we do not read learning material" – Week 7, Morning Group
Study is more fun	"It [the learning environment] is relaxing, joyful and easily comprehensible" – Week 14, Afternoon Group "PowerPoint presentations help students study more easily, help reviewing relax and enjoyably, help learning more surprising and exciting." – Week 15, Afternoon Group "In the lectures of other courses, teachers give lectures, students listen. Therefore, the atmosphere was not as exciting as in the optics classes." – Week 15, Morning Group "We heard that Mr Van is difficult. But when we study, we find that he is fun" – Week 14, Afternoon Group "This course is very friendly. In class, I have the feeling the teacher is like father or uncle. The feeling is different from the feeling in the other courses I have taken." – Week 14, Afternoon Group "I see the classroom is more fun, and my classmates talk and contribute to lessons more actively than they did at the beginning of the semester" – Week 15, Afternoon Group

Table 3.6 *An Example of Texts from the Lecturer's Interviews Coded into Free Nodes*

Free Nodes	Quotes
Students engaging in learning	Lecturer: "Students engaged in the learning activities in the classes well." "This week is the fourth week. From my observation, there were changes in positive direction. The students gained knowledge when they prepared for the lessons or carried the tasks the lecturer required. For example, last week students were required to prepare for the presentation and solve assignments. The students understood the requirement of the lecturer and prepare for them carefully." "Therefore, during the past four weeks of this semester, I almost did not teach knowledge. But I request them to prepare the lessons and present. By preparing and presenting the lessons, the engagement in learning is enhancing among majority of students, the number of students engaging well in learning is multiplying. Most of students read the lessons in advance before going to class. I checked them and knew that they all read the reading material." Teaching assistant: "Students were in good attitude and spirit. They presented carefully. They have prepared enough for the lesson and assignments. For preparation time, it is quite limited for them. They just finished chapter two last week. This week, they need to prepare for chapter three and assignment for the chapter"
New way of teaching and learning	Lecturer: "The second point is students' deploying MS PowerPoint. We need to consider it again. It is because it is new for the students. They never did something like this before. " "I am not teaching this year. The students present the chapters [smile]." "For example, when students presented, they don't know where to emphasise. It is inevitable. Why? Because they did not have much experience about that. We need to guide them. We guide them with a model example. They follow that and can explain. At the end or at the beginning of a class, I usually remind them or systematise or check again the key content to know how students understand the content." "We should not blame them because of the way they originally explained things. It is because they were influenced by the previous courses. Under those circumstances, they did not have a chance to learn how to explain. When they have the chance to learn the way, they can do it."

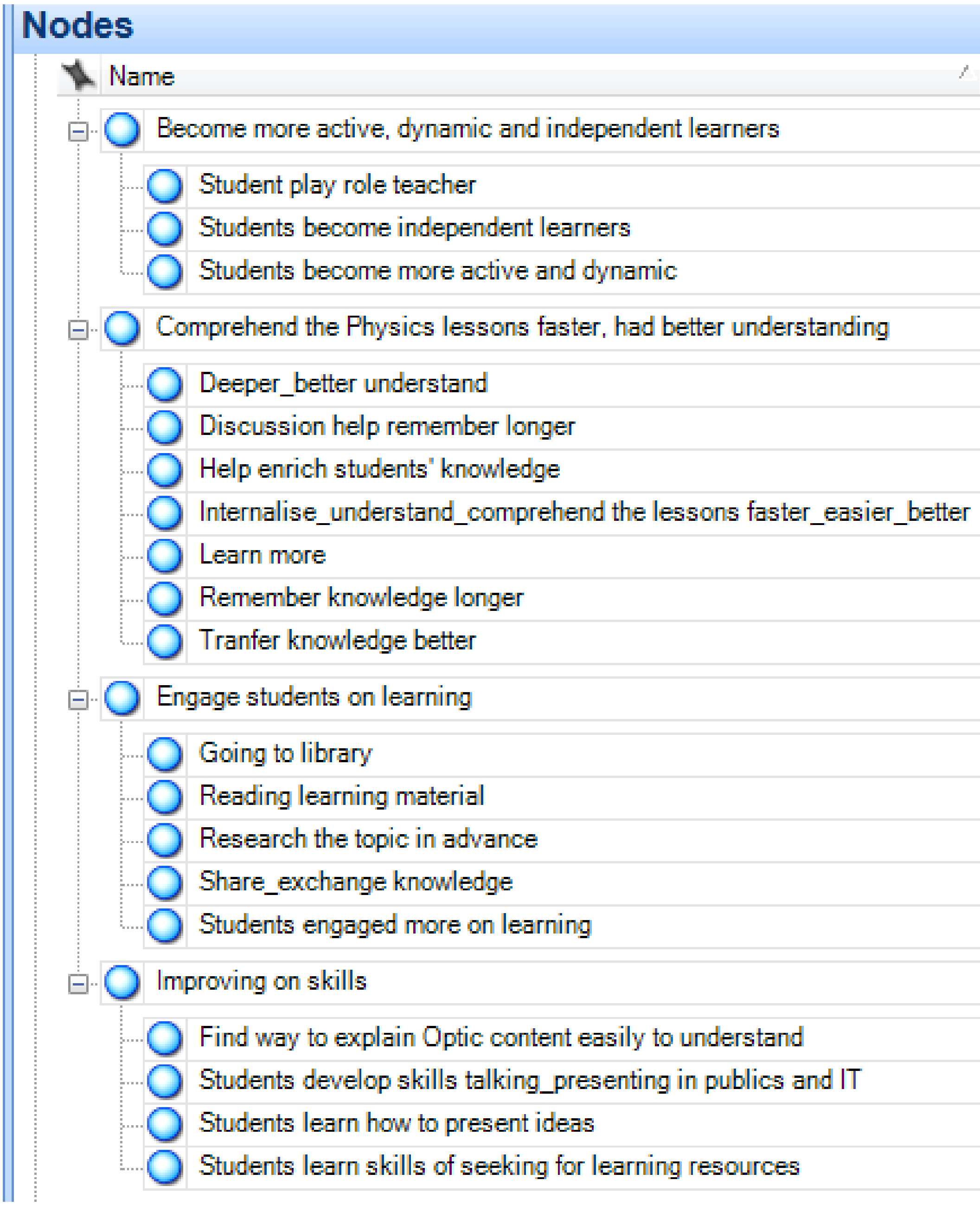


Figure 3.9 Combining free nodes (open codes) into parent nodes (axial codes) – Student interviews

The free nodes were then categorised into axial codes (parent nodes) (Cohen et al., 2011; Marshall & Rossman, 1995). In *Figure 3.9*, a group of free nodes whose referents reflect similar meanings were combined into an axial code. For instance, a group of five free nodes (e.g. '*Going to library, reading learning material*', '*Research the topic in advance*', '*Share_exchange knowledge*' and '*Students* *engaged more on learning'*) appears to indicate students' engagement in learning. Thus, the five nodes were put together under the parent node '*Engage students on learning*'.

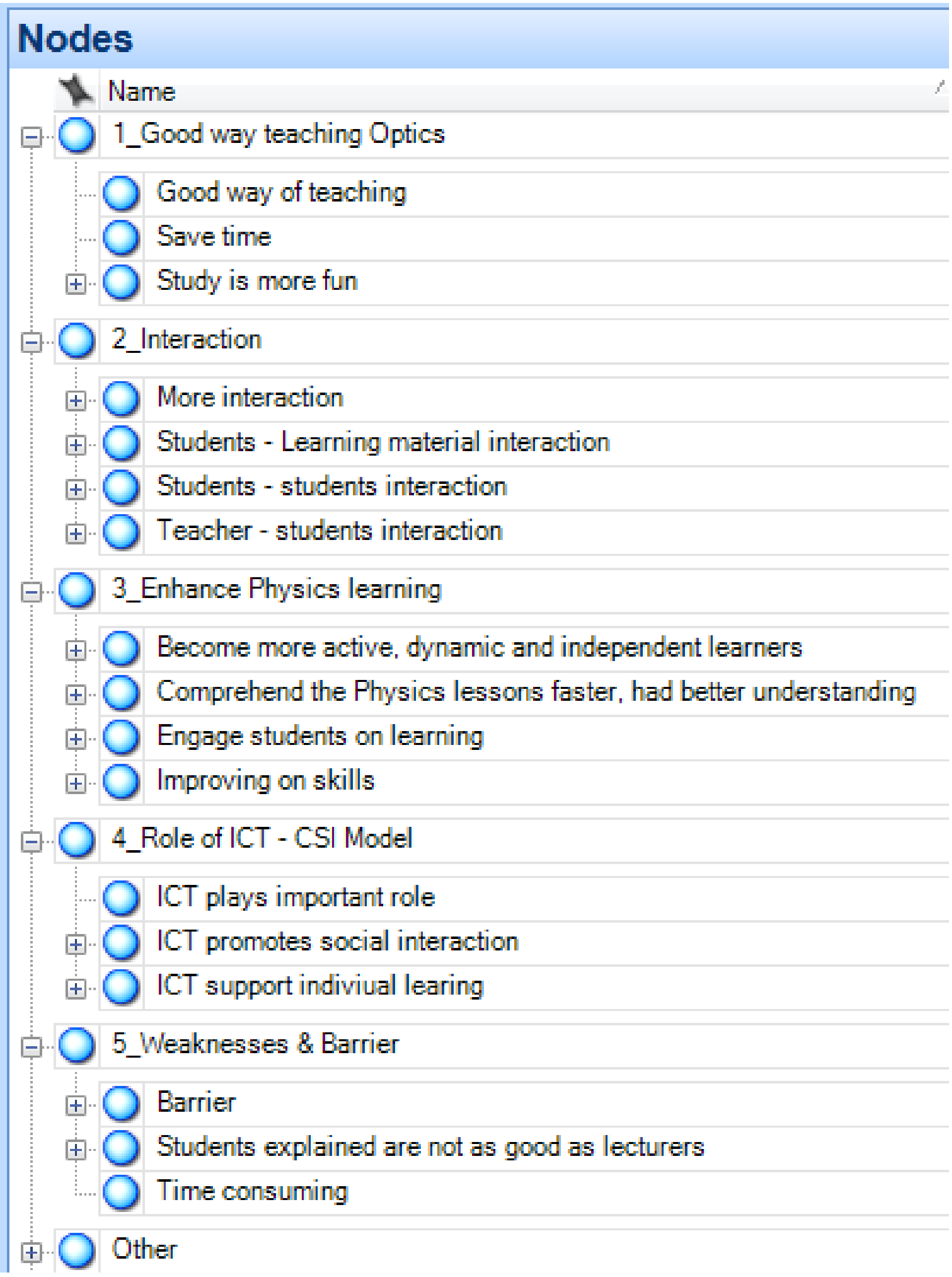


Figure 3.10 Combining parent nodes into typologies (grandparent nodes) in the light of research questions and theoretical framework – Student interviews

The parent nodes were then combined into typologies (grandparent nodes) in the light of research questions and the theoretical framework (Marshall & Rossman, 1995). The free nodes which did not fit with research questions were also categorised into grandparent nodes. These processes of coding allowed flexibility where data not aligned with the pre-determined theoretical framework and the research questions could also be recognised and analysed.

Figure 3.10 demonstrates how the parent nodes were categorised into grandparent nodes with the guide of research questions and the theoretical framework. The four parent nodes presented in *Figure 3.9* (e.g. '*Become more active, dynamic and independent learners'; 'Comprehend the Physics lessons faster, had better understanding'; 'Engage students on learning';* and '*Improving on skills'*) were categorised into a grandparent node – '*3_Enhance Physics learning*' in *Figure 3.10*. Similarly, other parent nodes were grouped into five different grandparent nodes. Among those five nodes, the node '*4_Role of ICT - CSI Model*' connected to the role of ICT in the CSI Model; and the two nodes '*2_Interaction*' and '*3_Enhance Physics learning*' related to two research questions:

1. Does the application of the pedagogic model increase interaction within the learning environment?

2. Does the application of the pedagogic model improve students' Optics test results?

The parent nodes which do not directly related with the research questions or the theoretical framework such as '*1_Good way teaching Optics*', '*5_Weaknesses & Barrier*', '*Other*', and '*Suggestion*' were also categorised into grandparent nodes. These nodes could be considered as emerging themes and the findings associated with them will be presented if the numbers of references were sufficiently high.

3.7 Chapter Summary

This chapter described the research methodology, methods of data collection and data analysis. First, the chapter discussed two important paradigms in science education research, positivist and interpretive paradigms, in terms of ontology, epistemology and data collection methods. A positivist approach has some major advantages in this context. In positivist research, theories are investigated by implementing and measuring through quantitative instruments (e.g. tests and questionnaire). The quantitative data collection methods allow researchers to test a theory and investigate effects of the theory on participants; and findings are possibly generalizable and transferable. However, one disadvantage of positivist research is that it may not address human beings as agents who are determined by external environments and also actively determine their environments. In contrast with positivist research, interpretive research investigates a human being as an agency with social and cultural background. Qualitative data collection methods (e.g. interviews and observations) originated from an interpretive paradigm, permitting researchers to gain insights and understandings of how a theory influences participants as sociocultural agents.

The goal of the research was to develop, trial and evaluate a pedagogic model which integrates appropriate learning principles with ICT for the teaching of Physics in the context of Vietnam. Based on the research goal, a research framework with two research phases – *the model development* and *the model implementation* - were designed. Depending on the aim of each phase, qualitative methods from an interpretive paradigm as well as quantitative methods derived from positivist paradigm were employed.

The aim of the first phase of the research – *the model development* – was to develop a pedagogic model. The model was developed based on the Vietnamese context and current research, then examined by experts renowned in the science education area. Rich feedback of the experts from different backgrounds and critical reflection of the experts' feedback were very important for the improvement of the model. Therefore, a qualitative data collection method – *online evaluation* - was chosen.

The aim of the second phase of the research – *the model implementation* - was to investigate whether the implementation of the model helped (1) increasing interaction within the learning environment, (2) improving students' physics scores and (3) enhancing students' critical thinking skills. To accomplish these aims, quantitative methods were utilised as major methods of data collection. These methods included critical thinking skill tests, optics tests, in-class observations with two observers scoring the degree of interaction, and questionnaires. Different quantitative methods (e.g. tests, questionnaires and scores by two observers) were used to measure and investigate the effects of the CSI model on the students' learning, as well as assist triangulating and supplementing the data.

Furthermore, a qualitative data collection method – interview - was also used in this phase of the research to help enrich and triangulate the data. Interviews with the lecturer, the teaching assistant and students were conducted. The purpose of interviewing people from different groups was to get voices from different perspectives (e.g. students, a lecturer and a teaching assistant). This would facilitate triangulating information. In addition, data from student interviews might disclose viewpoints which had not been revealed in interviews with the lecturer and the teaching assistant, and vice versa.

In the next two chapters, findings from the two research phases will be presented. Chapter four will provide an insight into the pedagogic model development, results and critique discussion of the experts' evaluation. The chapter will also provide detailed explanation of the model. Chapter five will describe the implementation of the model and present findings from interviews, tests, observations and questionnaires.

Chapter 4 The Development of the Pedagogic Theoretical Model of Integrating Constructivist and Sociocultural Learning Principles with ICT

As mentioned in the summary of Chapter 3, this chapter will present the development of a model which integrates learning principles and ICT in teaching. It will begin with outlining the process of developing the model which includes seeking and analysing feedback from the experts, as well as revising the model. The detailed explanation of the revised model which was named the CSI Model will then be provided.

4.1 The Development of the CSI Model

The first generation of the pedagogic model (*Figure 4.1*) was built on two constructivist learning principles, one of which originates from cognitive constructivism; the other from social constructivism. Salomon (1998) pointed out that the basics of cognitive constructivism originated from Piaget and focuses on individuals and the way they construct their knowledge. Based on this view, cognitive constructivist teachers aim at developing the skills and knowledge of individual students. In contrast, notions of social constructivism, derived from Vygotsky (Powell & Kalina, 2009), emphasises interactions in learning processes.

4.1.1 Expert Evaluation of the Model

The first generation of the model presented in Chapter Two was designed on the basis of current studies and the context of Vietnam (*Figure 4.1*). After this pedagogic model had been created, experts in science education were invited to evaluate it. The objectives of the expert-evaluation were (1) to determine to what extent the model is suitable for teaching and learning, and (2) to ensure it is valid in its representation of the theoretical framework. The experts noted the strengths of the model and suggested changes for improvement.

The experts' feedback indicated that this pedagogic model adequately reflects the nature of learning and the role of ICT. A synthesis of the feedback indicates that the model has main strengths. First, the model provides a reasonable pedagogic framework which includes the individual and social aspects of learning. It was commented that "it [the model] does provide a reasonable framework" and "strong points are around the attempt to include the cognitive as well as the social".

The role of ICT in the model is considered as a second strong point by the experts, who stated:

> A remarkable point in this model is that the research has exploited the role and effectiveness of ICT. ICT has actively supported learning processes of students; and the value of the model has been indicated by the use of ICT in learning and teaching in the current context.
>
> The strong points are around the attempt to include ... the role that ICT might play.

Third, the pedagogic value of the model was recognized. For example:

> [The pedagogic model] promotes the role of learning, regarding the student-centred approach, and is very appropriate for the current educational context where information is proliferating.
>
> [The model encourages] the acquisition of self-learning, problem-solving and cooperation skills for learners.

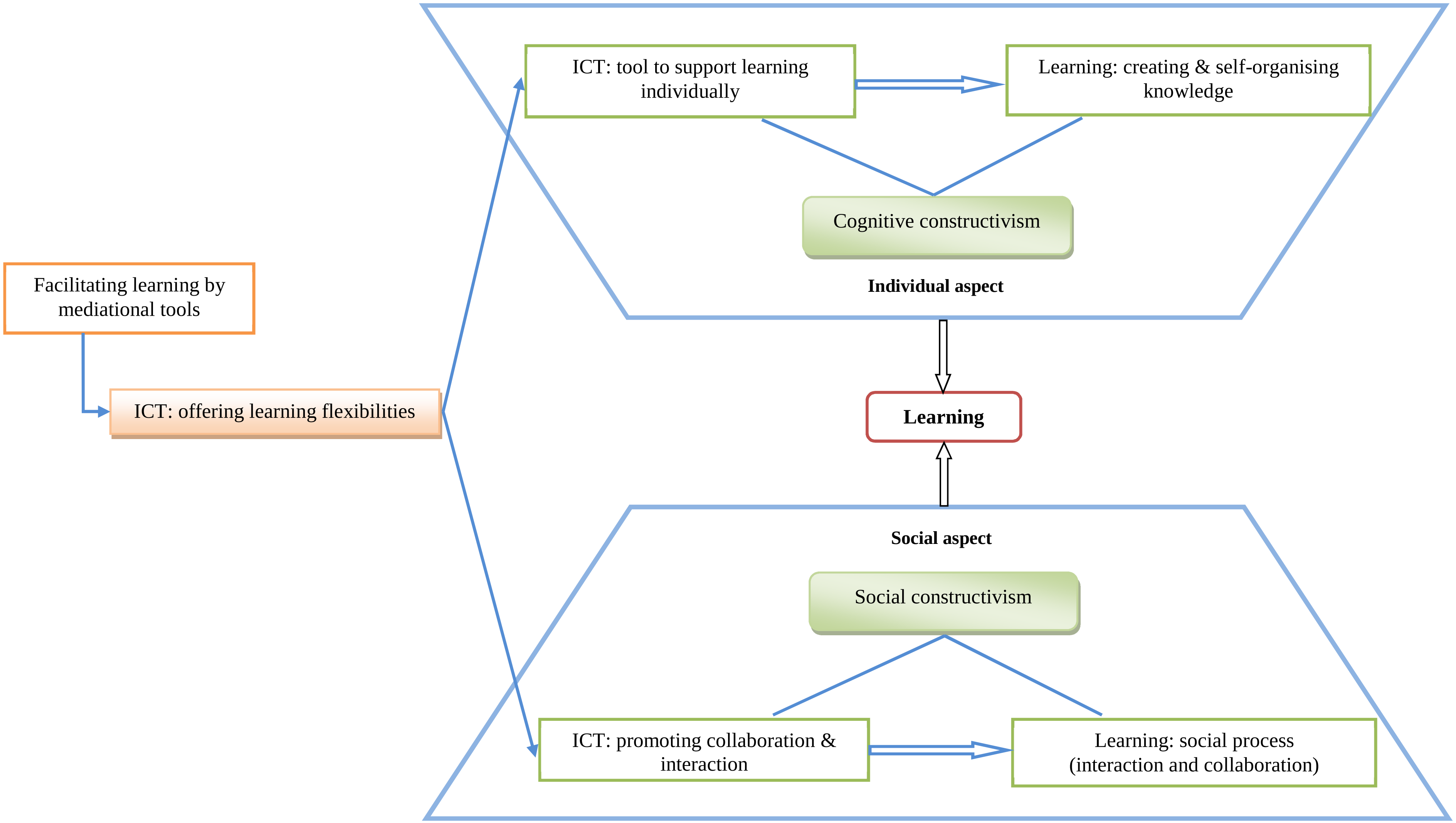


Figure 4.1 First generation of the model: the Pedagogic Theoretical Model of Integrating Constructivist Learning Principles and ICT

The idea reflected in the pedagogic model that learning involves both the social and personal construction of knowledge, was appreciated by the New Zealand experts. The Vietnamese expert tended to value its appropriateness to his education context, where the use of ICT in education and student-centred approach is strongly promoted. The role of ICT in the model is considered important by experts from both cultures.

Apart from the strengths of the model, the experts also pointed out its limitations. According to an expert, the use of the phrase “learning is a social process” may imply that thinking and language are the same thing from a discursive view. It is presented in the model that language as a meditational tool differs from thinking itself. It was suggested that this phrase should be changed to make its meaning clearer.

According to the experts, the rationale for the social aspect of learning could be improved. It was advised that:

> The section on the social aspects could be strengthened to include the background of the students in terms of identity and agency.
>
> The model can be applied if the following condition is satisfied: learners’ attitude; learners deem learning as their own responsibility, and they learn actively and spontaneously under the guide of teachers.

The experts also suggested that on the social aspect, the model seems to focus on collaboration, rather than cognition processes. “The weaknesses are that the social aspects of learning are underplayed and tend to be related to collaboration rather than ways of knowing and coming to know”, stated one of the experts.

From the individual perspective, it was explained that “learning normally starts by observing or experiencing” and “educators can facilitate student learning by offering them as many opportunities to observe and to experience in a learning context". One expert argued that the explanation concentrated on physical stimuli and disregarded social stimuli. It was suggested that the model could be improved by including sociocultural views.

The Vietnamese expert commented that the model seems to ignore the teachers' role. Although the role of students is the centre of learning processes, the important role of teachers should be taken into account. The researcher agreed that the role of the teacher is essential, and that this view was not adequately emphasised.

One expert mentioned that, besides students' attitudes, two other conditions affecting the application of the model were the development of ICT and teachers' competencies. Teachers' competencies include subject matter knowledge, pedagogic knowledge, and abilities to organise and control students' learning activities. The expert claimed that competencies could be developed through teachers' training programmes which were designed in the light of the learner-centred approach. The programmes should focus on encouraging active learning, fostering self-learning and problem solving skills. To improve the competencies of the current teachers, workshops and conferences on constructivism could be organised.

In summary, from the experts' views, the pedagogic model had some weaknesses:

- The rationale on the individual aspect appears to emphasise on physical stimuli.
- The conditions for implementing ICT in teaching such as infrastructure and teachers' competencies need to be mentioned.

- Teachers' role seems to be neglected
- The phrase "learning is a social process" should be revised, and the social aspect should be strengthened.

The following section discusses a critique on the comments and presents the revision of the pedagogic model based on this critique.

4.1.2 Critique of Model Evaluation

On the individual aspects of the model, it was stated by the experts that "learning normally starts by observing or experiencing" and "educators can facilitate students by offering them as many opportunities as possible to observe and to experience in a learning context". One expert argued that the explanation concentrated on physical stimuli and disregarded social stimuli. Nevertheless, the model has included the role of "mediational tools" (e.g. signs, diagrams, language, experimental equipment, technical tools and technology) in the process of the social construction of knowledge. Language and other tools, especially ICT, are important for promoting interaction, discussion and socially constructing knowledge as well as individually constructing knowledge, which normally begins with experiencing and observing.

One expert suggested focussing on teachers' competencies and infrastructure as a condition for implementing the pedagogic model. Teachers' subject knowledge and pedagogical competencies are significant in the use of ICT (Mishra & Koehler, 2006). The importance and inter-relationships of subject content knowledge, pedagogy knowledge and technology knowledge, which are mentioned in the expert comments, have been interpreted in the Technological Pedagogical Content Knowledge (TPCK) Model by Mishra and Koehler (2006).

The expert's comment also relates to the infrastructure or the development of ICT. ICT infrastructure is certainly important for the use of ICT in teaching. The factors influencing the application of ICT at an institutional level are outlined by Collis and Moonen (2001).

This comment (focus on teachers' competencies and infrastructure) may be useful at the institutional level for leaders, managers, heads of institutions, and deans of faculties who want to set up a systematic implementation of ICT in their institutions. However, the goal of the pedagogic model is to propose a framework for teachers to implement ICT effectively. The model is in the form of a pedagogic theoretical framework which recommends educational strategies for teachers. It does not address implementation of ICT at an institutional level but at the teachers' level. When the infrastructure, policy, support and other factors are available to some extent, teachers will need a pedagogic model for their integration of ICT in teaching. The current model will provide insights about the nature of learning and the way of using ICT to support learning effectively.

4.1.3 Revising the Model

After the evaluation and comments from experts were analysed, it was concluded that the model's enhancements would focus on three issues: the discussion on the teachers' role, the use of terms and the social aspect of learning. These three issues relate to the last two bullet points of the weaknesses of the model which was presented by the end of Section 4.1.1:

- Teachers' role seems to be neglected
- The phrase "learning is a social process" should be revised, and the social aspect should be strengthened.

4.1.3.1 The Discussion on the Teachers' Role

An enrichment of the pedagogic model is further description about the teachers' role. As mentioned in Chapter One, Vietnamese education is strongly influenced by Confucian philosophy; thus, teachers have a very important and high position in society generally, and in the classroom specifically (Ellis, 1994; C. Nguyen, 2012; H. P. Nguyen, 1974). As this model is intended to be implemented in Vietnam, an appreciation of the status of the teacher should be indicated.

Teachers play an essential role in students' learning processes. Teachers design curriculum, courses and learning tasks. They decide the body of knowledge and skills, organise learning activities and guide students to learn. Teachers' encouragement and support are important not only for students' learning but also for motivating students in the process of meaning-making. The role can sometimes be compared with forces in Mechanics. Teachers exert forces on learners in duration of time. Learners accelerate and have a certain amount of momentum to discover the world. Teachers now and then help learners accelerate when it is necessary. The pedagogic model describes the role of ICT in learning, but does not imply that teachers are not important in the model. The role of teachers is vital and cannot be displaced by ICT or any pedagogic models. Teachers are the ones who use this pedagogic model and ICT. The effectiveness of the model implementation strongly depends on teachers' professional competency.

Although the role of teachers is very important, teachers cannot learn for students or cannot upload knowledge to their brains like it is possible to do with computers. Students have to construct knowledge themselves. This research will not discuss teachers' roles in general, but will focus on the role of teachers as facilitators or mediators who help learners co-construct knowledge. Knowledge of mankind generally and Physics knowledge particularly have been developed over a long period of time, and the volume of knowledge is very large. Teachers need to guide students to discover useful knowledge and make it meaningful.

Teachers also play the role of social agents, facilitating students' learning. By well-designed learning tasks and students' group-work, guidance, feedback and encouragement, teachers provide students with opportunities to participate actively in team-work and so co-construct their knowledge (Salomon & Perkins, 1998). Interactions between teachers and students are important for fostering student's learning. With well-designed group-learning tasks, teachers can help students achieve development in their learning that is beyond the level of development that individual students can achieve when they work alone. This can be explained from the perspective of social mediation of individual learning which will be discussed in Section 4.2.2.1, *The Nature of Learning*. When a group of students work together, they interact with each other. Each member of the group can play the role of a social agent facilitating other members in their learning. In addition, more competent students as social agents can help individual students who are less competent in their learning process.

4.1.3.2 The Use of Terms

An expert commented that the phrase "learning is a social process" is imprecise; and it was recommended to be changed into "learning occurs in social contexts". As a result of the revision, the two learning principles will be: (1) learning requires learners to create and to self-organise their knowledge, and (2) learning occurs in social contexts.

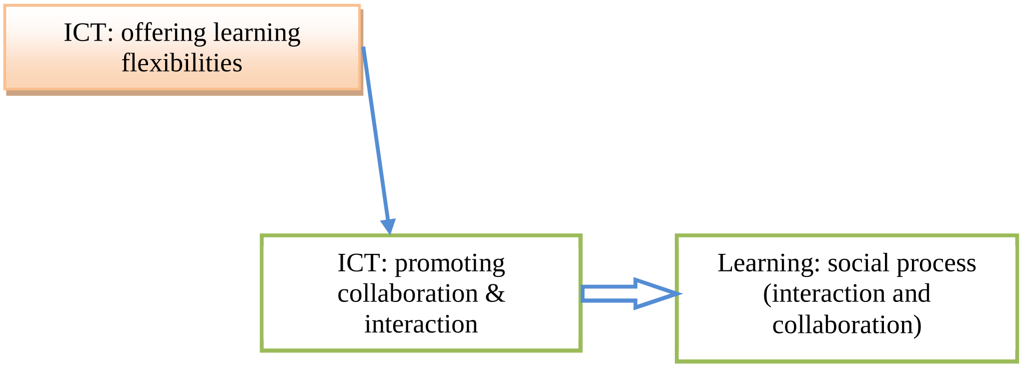


Figure 4.2 Social aspect of learning

Furthermore, it is included in the model that "ICT: promoting collaboration & interaction" (see *Figure 4.2*); and the term "collaboration" was not obviously mentioned in the description of the first generation of the model. For clarification and simplicity of the pedagogic model, the term "interaction" will replace the term "collaboration & interaction". Interaction in this context means interaction between students – learning materials and learning tasks, between students - teachers and between students - students. "Collaboration" is implied in "interaction" between students.

4.1.3.3 The Social Aspect of Learning

An important adjustment to the model relates to the social aspect of learning. Salomon and Perkins (1996) identify two versions of learning as a social process. The first version explains learning from the social constructivist perspective. It is argued that this version regards the central role of collaboration, but emphasises individual learner's achievements supported by collaboration and group-work; thus the first version is considered a weak version as described by Salomon and Perkins (1996). The second version, considered as the strong version, is "learning is socially distributed" (Salomon & Perkins, 1996, p. 9). Solomon and Perkins notes that "What is learned and the thinking processes behind learning often are socially and physically distributed, features of the group and physical artifacts involved, not just of individual minds" (Salomon & Perkins, 1996, p. 10).

Based on social constructivism, the model is not able to explicitly explain how interaction and collaboration support the social construction of knowledge. Social constructivism emphasises the role of social factors in learning; but does not explain how the meditational tools facilitate learning socially. In contrast, sociocultural views do present in detail ICT as tools or artifacts and how the social aspect of interaction can enhance learning (see Section 4.2).

Bell (2005) discusses three sociocultural views related to learning: learning as situated activity, learning as distributed cognition and learning as mediated action. The usefulness of these views for the model is that learning occurs in a social and cultural context, and knowledge is shared across the social context. Students interact with the social settings and co-construct their knowledge by employing artifacts (e.g. signs, diagrams, language, experimental equipment, technical tools and ICT). Sociocultural theories are more appropriate for the pedagogic model than social constructivist theory, especially in terms of the use of ICT as artifacts, so it would be appropriate for them to be used as a foundation for the social aspect of learning in the model. As a result, the name of the model was modified to '*The Pedagogic Theoretical Model of Integrating Constructivist and Sociocultural Learning Principles with ICT*'.

To conclude this section, the feedback of experts was valuable in the development of the model. The pedagogic model has been modified and improved based on the suggestions of the experts. The most significant adjustment is that sociocultural theories are more emphasised in the revised model which is presented in *Figure 4.3*.

4.2 The Pedagogic Theoretical Model of Integrating Constructivist and Sociocultural Learning Principles with ICT (the CSI Model)

Based on a review of literature, the context of Vietnam and the result from experts' evaluation, a pedagogic theoretical model has been developed. The framework is built on constructivist & sociocultural learning principles.

4.2.1 An Overview of the Model

Figure 4.3 presents the Pedagogic Theoretical Model of Integrating Constructivist and Sociocultural Learning Principles with ICT. In general, the nature of learning can be explained by cognitive constructivist and sociocultural points of view: learning means creating and self-organising knowledge (cognitive constructivism), and learning occurs in social context (sociocultural theories). The individual aspect of learning and the use of ICT to support learning individually were discussed in Chapter 2. This section will concentrate on the social aspect of learning and the use of ICT to support learning socially.

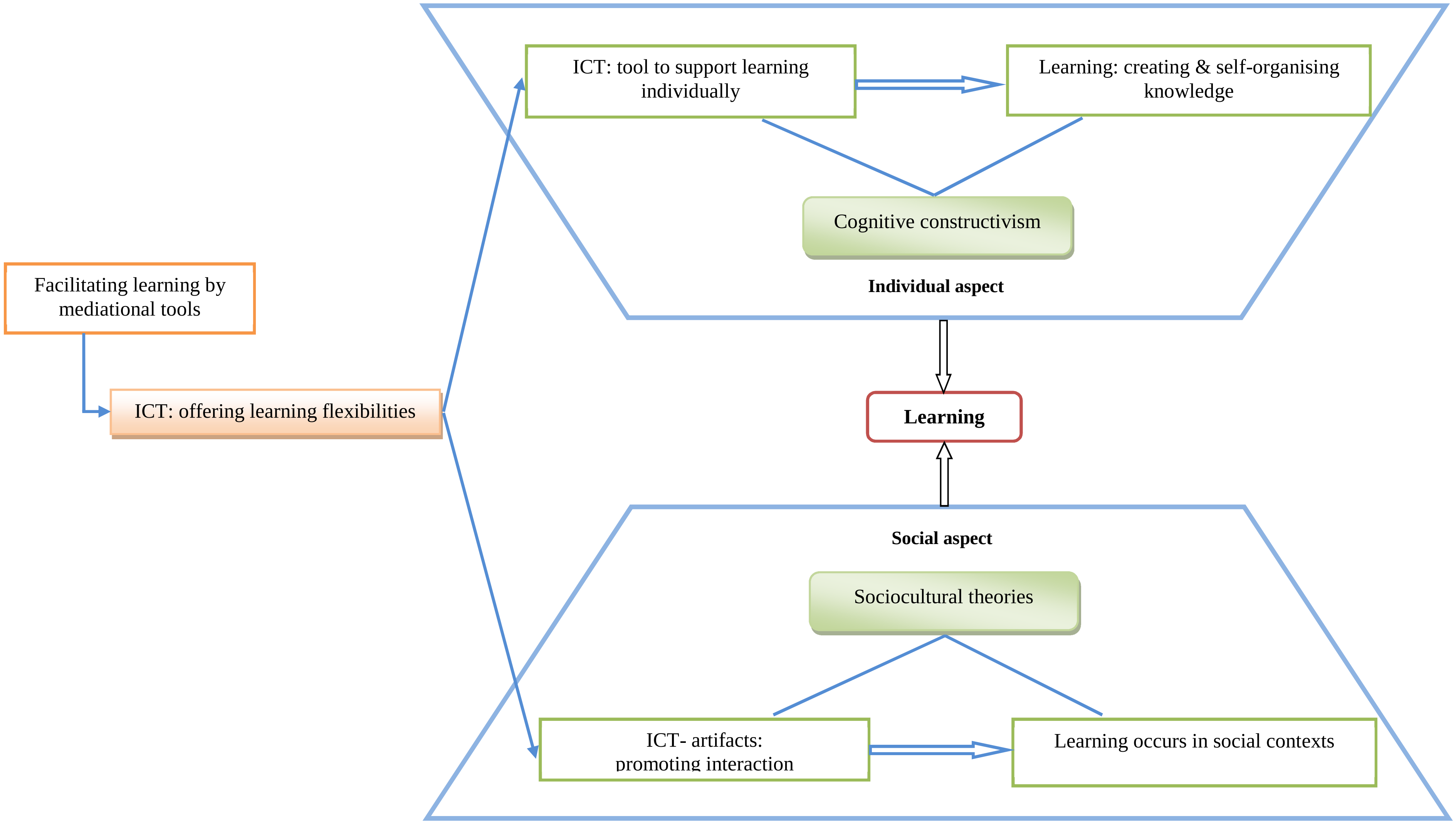


Figure 4.3 The Pedagogic Theoretical Model of Integrating Constructivist and Sociocultural Learning Principles with ICT (The CSI Model)

4.2.2 Sociocultural Learning Principle

4.2.2.1 The Nature of Learning

The nature of learning from a sociocultural perspective is discussed by Salomon and Perkins (1998), who distinguish meanings of social learning. Some of these meanings are:

- active social mediation of individual learning,
- social mediation as participatory knowledge construction,
- social mediation by cultural scaffolding,

This model concentrates on the above meanings of the learning for the following reasons. The first meaning of learning - *Active social mediation of individual learning* - reflects the idea that in society, facilitating agents (i.e. a team or a person) help an individual to learn by providing the learner with guidance, tasks, feedback, scaffolding and so on. This meaning of learning - *Active social mediation of individual learning* - is useful for the clarification of teachers' role which was discussed in Section 4.1.3.

The second meaning of learning – *Social mediation as participatory knowledge construction* – views learning as participating in a social process of knowledge construction. This type of outlook is also shared by several researchers in the field including Cole (1995) and Greeno (1997).

> Social mediation of learning and the individual involved are seen as integrated and highly situated system in which the interaction serves as the socially shared vehicles of thought. Accordingly, the learning products of this system, jointly constructed as they are, are distributed over the entire social system rather than possessed by the participating individual (Salomon & Perkins, 1998, p. 4).

Social mediation by cultural scaffolding – the third meaning of learning – is interpreted by Salomon and Perkins (1998) that learning could be mediated by cultural artifacts such as tools (e.g. books, photos and videos) and information sources.

> Such artifacts can range from books and videotapes that tacitly embody shared cultural understandings to statistical tools and socially shared symbols embodying, for instance, a "language of thinking" that includes such finely distinguished terms as hypothesis, conjecture, theory, and guess (Salomon & Perkins, 1998, p. 5).

The purpose of employing sociocultural views is to underpin a learning principle in the CSI Model through the use of ICT. Therefore, the two meanings of learning - social mediation as participatory knowledge construction and social mediation by cultural scaffolding – are important to this research.

4.2.2.2 A Sociocultural Learning Principle: Learning Occurs in Social Contexts

The second learning principle is based on the sociocultural view that learning occurs in social contexts (*Figure 4.4*). This principle relates to the second perspective of learning identified by Salomon and Perkins (1998): social mediation as participatory knowledge construction. It is also based on the notions of distribution of cognition and situated learning.

Cognition (i.e. intelligence or knowledge) is distributed across social systems among people, learners, cultures, artifacts, environments and situations (Pea, 1997; Salomon & Perkins, 1996; Salomon & Perkins, 1998). It is argued that cognition (i.e. intelligence) is accomplished rather than possessed by individuals participating in learning activities (Pea, 1997; Salomon & Perkins, 1998), and “learning is participation in social practice” (Greeno, 1997, p. 9). In other words, according to the authors, cognition or intelligence is achieved by participating in social activities.

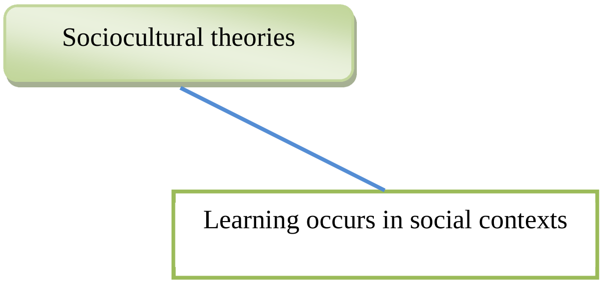


Figure 4.4 The second learning principle

According to Pea (1997), the distribution of cognition has two dimensions: social and material. The social distribution of cognition relates to the cognition constructed by participating in social organised activities such as working in groups to accomplish shared goals. In this outlook, acquisition of learners’ knowledge and skills occurs when they participate in social practices (Cobb & Bowers, 1999; Greeno, 1997; Salomon & Perkins, 1998). Therefore, “discussion of alternative arrangements for learning needs to include consideration of the values of having students learn to participate in the practices of learning that those arrangments afford” (Greeno, 1997, p. 10). The material distribution of cognition concerns the cognition constructed by utilising artifacts to accomplish activities’ goals. Thus, when designing learning tasks for students, sociocultural educators are concerned with designing group-work activities so that students have opportunities to participate and work in groups. The students interact and collaborate with each other when they conduct the learning task and co-construct their knowledge and skills.

Inclining to the view that learning is facilitated by participating in social practices (Cobb & Bowers, 1999; Lave & Wenger, 1991), it is argued that "knowledge is situated, being in part a product of activity, context, and culture in which it is developed and used" (Brown et al., 1989, p. 32). Besides the notion that learning is situated in contexts and activities, cultural views also emphasises interactive activity systems in which learners interact with other people (i.e. other learners, teachers and tutors) as well as artifacts (i.e. tools, ICT and learning resources) (Cobb & Bowers, 1999; Cole & Wertsch, 1996; Greeno, 1997).

4.2.3 ICT Facilitating Learning Which Occurs in Social Contexts

It was discussed in Chapter two that ICT can facilitate learning by providing learning flexibilities (Collis & Moonen, 2001). This section will explain how ICT as an artifact may promote interaction and facilitate the co-construction of knowledge in social contexts (*Figure 4.5*). It is considered that interaction in this model contains interaction between (1) students – teachers, (2) students - students and (3) students – learning materials and learning tasks.

According to Collis and Moonen (2001), learning flexibilities relate to learning resources such as textbooks, books and online resources. Beside traditional resources (i.e. textbooks, books and other resources in libraries), students are provided with opportunities to access unlimited online resources created by scientists, experts, lecturers, peers and communities. These resources are rich as well as variable in format such as texts, photos, diagrams, animations, audios and videos. Students have opportunities to interact with the learning resources, exploit these ICT artifacts to engage in a meaningful learning activity and co-construct knowledge (Pea, 1997; Salomon & Perkins, 1998).

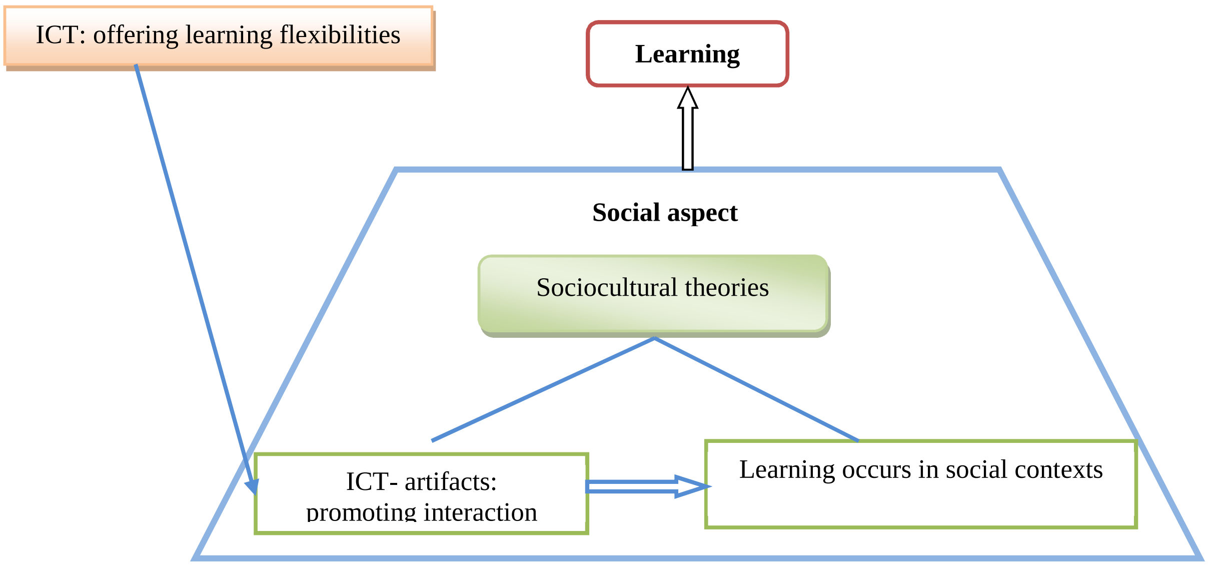


Figure 4.5 ICT supporting learning on social aspect

The flexibilities provided by ICT extend to methods of communication such as face-to-face, telephone, e-mail, chat, video conferencing and forum (Collis & Moonen, 2001). The communication can be synchronous or asynchronous. These flexibilities in communication offer opportunities for teachers and students to promote discussion and interaction (Jonassen et al., 1995), and so provide a supporting environment for learning in the collective (Thomas & Brown, 2011).

As discussed earlier, discussion and interactions among learners and learners-teachers in interactive social systems are the corner stones of learning which is based on a sociocultural approach. The power of ICT as sociocultural artifacts is reflected on its capabilities to promote discussion and interaction. With the support of the communication function of ICT, students can work in groups, solve problems or conduct designed learning tasks. They can present their arguments, negotiate meaning and co-construct their knowledge. Besides interacting with their peers, ICT is able to provide the students with opportunities to interaction with teachers, tutors and experts from whom they can get support, guidance and scaffolding. By providing a wide range of choices in communication methods, ICT can support and enhance the students' learning.

Collis and Moonen (2001) also point out that ICT can offer students choices in instructional organisation including forms of course-organisation (e.g. face-to-face and online), time, place and pace of study. Furthermore, ICT also supports alternatives in the social organisation of learning (e.g. working in groups, working individually and combination). The flexible choices offered by ICT provide learners with a variety of opportunities to participate in learning activities and social practices without depending too much physical places. The participation in social practices by students crosses physical locations and occurs online when individual students can be in different places (e.g. at home, in café, in library and so on) and work together on a shared task. Students can also participate in learning activities any time. To a certain extent, they can also decide their pace of study, language, and method of working in groups and/or individually. The above flexibilities which are facilitated by ICT encourage learners to participate in social systems and engage with new knowledge.

As mentioned in Section 4.2.2, students' knowledge is constructed when they achieve shared goals. The students learn by participating in interactive social systems in which individuals interact with each other (students and teachers) and interact with artifacts (i.e. ICT), including learning resources designed by teachers and others (Greeno, 1997; Salomon & Perkins, 1996). The flexibilities of ICT in terms of communication, instructional organisation, time, place, social organisation of learning can help to promote interaction and discussion within the interactive social systems, therefore enhancing students' learning.

4.3 Chapter Summary

This chapter presented the development and evaluation of a pedagogic model which integrates ICT with constructivist and sociocultural learning principles. In the model, ICT is presented as a tool which offers considerable learning flexibilities. It supports internal learning processes (creation and self-organisation of knowledge - cognitive constructivism) and promotes interaction (social processes of learning – sociocultural views).

The model had been developed based on these principles and subsequently evaluated by New Zealand and Vietnamese experts in science education. The pedagogic model, as commented by the experts, reflected the nature of learning and the role of ICT. The strong points of this model from the experts' perspectives were (1) a reasonable pedagogic framework which includes the individual and social aspects of learning, (2) the role of ICT in the model, and (3) the pedagogic value of the model. The experts also advised changes to improve the model, and based on their advice, adjustments have been made. The most important adjustment is that sociocultural views were employed as a foundation for the social aspect of learning in the model. The name of the revised model, therefore, was modified into '*the Pedagogic Theoretical Model of Integrating Constructivist and Sociocultural Learning Principles with ICT' (The CSI Model)*

In general, ICT in the CSI Model is considered as a tool to support individual learning processes and the social processes of learning. The learning principle in the model from the individual perspective – '*learning is creating and self-organising knowledge*' - is underpinned by cognitive constructivism. From the social aspect, the learning principle: '*learning occurs in social contexts*' is enlightened by sociocultural theories.

Cognitive constructivist and sociocultural perspectives may be regarded as two independent perspectives. However, it is argued that the two perspectives are considered to have a reciprocal relationship. (Cobb, 1994; Salomon, 1998; Salomon & Perkins, 1998; Steffe, Cobb, & von Glasersfeld, 1988). Cognitive constructivist and sociocultural perspectives reflect two mutual aspects of dynamic social and individual learning processes: “We have a cycle of acquiring that which is socially constructed as a shared meaning or a shared artifact, affecting a child’s cognitive repertoire, which is then used to affect that child’s social participation” (Salomon, 1998, p. 6).

Chapter 5 Findings – The CSI Model Implementation

As mentioned in Chapter 3, this research is presented in two phases: (1) the Model Development and (2) the Model Implementation. The journey of developing a suitable pedagogic model for the Vietnamese context has been narrated in Chapter four – *the Development of the CSI Model*. The implementation of the CSI Model and the findings from the range of data sources will be presented in this chapter.

In this second phase of the research, quantitative data collection methods were used as the main methods of data collection while qualitative methods were used to support and triangulate the main data collection methods. The quantitative data collection methods employed in this research included optics tests, critical thinking skills tests, observation schemes and scores and students' questionnaires. Interviews with lecturer, teaching assistant and students were used as qualitative data collection methods.

Chapter five contains four sections. The first section will describe briefly how the CSI Model was implemented into teaching practice. Following the descriptive reasoning in first section, findings from qualitative data were then interpreted. The third section presents the findings from quantitative data, the main sources of data (e.g. optics tests, critical thinking tests, observation schemes and questionnaires), and the final section will discuss data triangulation.

5.1 The Implementation of the CSI Model

The CSI Model was implemented in an Optics Course of an undergraduate programme at a Vietnamese university by a lecturer named Van. A Vietnamese version of this pedagogic model and detailed explanation for it was provided to

Mr Van in the form of a booklet of ten pages (Appendix 4). Mr Van was asked to read the document carefully, and after a week a meeting between him and the researcher were arranged. In the meeting, the researcher explained the CSI model carefully to the lecturer, and then an intensive discussion between Mr Van and the researcher on the model occurred. After obtaining a deep understanding about the pedagogic model, the lecturer discussed with the researcher teaching strategies for the optics course based on this CSI model. With the support of the researcher, Mr Van then designed teaching strategies and learning tasks for his students; the CSI model was considered by him as a theory underpinning those teaching and learning activities.

There were two groups of students involved in the research: the Morning Group and the Afternoon Group. Each group was divided into small groups with about five students in each. Students formed their groups and chose members by themselves. The Morning Group had eleven small groups while the Afternoon Group had seven. The lecturer required the groups to research optics topics and to present the topics in front of class using Microsoft PowerPoint (MS PP).

The content of the Optics Course was covered in a book of readings. This book of reading had been designed by the lecturer and evaluated by a committee of the faculty. It was then revised and used as a textbook for optic courses provided by the faculty. The optics content of the course were organised into ten topics, including an optional topic:

Topic 1: Introduction

Topic 2: Interference

Topic 3: Diffraction

Topic 4: Geometry Optics

Topic 5: Polarization

Topic 6: The Transmission of Light

Topic 7: Thermal Radiation

Topic 8: Quantum Optics

Topic 9: Non Linear Optics

Optional topic: students chose a topic they were interested in

Each small group was requested by the lecturer to do research about an optics topic which would be discussed in the next class. The students then divided the work among group members, and used a range of sources for the information (e.g. textbooks, books and online resources). Each group then organised the information into PowerPoint slides and designed a presentation to explain the optics topic in the coming class.

It was compulsory for each group to have their learning material in the form of MS PP slides ready before each class. In class, the lecturer requested students from groups to explain the optics topic to the whole class. Mr Van and the class then asked the presenting groups questions, followed by discussions on the optics topic. He also supported the students' optics learning by a series of questions and explanations.

For the Morning Group, students' learning was supported by a learning management system (LMS). This LMS allowed students to upload and share their learning material including PP slides and to communicate and discuss online. The lecturer, the teaching assistant and the researcher were able to access the PP slides to see the representations of the optics content. Main learning activities that occurred on the LMS, which are displayed in Appendix 5, include:

- Students' submitting their optics presentations and sharing the presentations
- Students' forum discussions with the guide of the teaching assistant.
- Links directing to optics websites

Mr Van's teaching and his design of the students' learning activities are summarised in Table 5.1. The table also compares teaching and learning activities prior to and during the time the CSI Model was implemented.

To provide further details on the implementation of the CSI Model, the first optics class in the semester will be described as an example of how the lecturer started to implement the model into his teaching practice. Then, the lecturers and students' reflection on their experiences of the model implementation in the semester will disclose more insights into the implementation process.

Table 5.1 *Mr Van's Teaching and Students' Learning Activities Before and During the Time He Implemented the CSI Model*

Before this research	**During this research: using ICT underpinned by the CSI Model**
1. Prior to the classes: Students were asked to read optics learning materials	1. Prior to the classes: Students were asked to study optics topics by themselves (Figure 2.8, Figure 2.9, Figure 4.5): • Working in groups, • Using a range of learning resources (e.g. textbooks, books and online resources) • Designing presentations to explain the optics topics to their classmates in the coming classes • Sharing presentations on LMS (Morning Group)
2. In the classes: The lecturer gave optics lectures The lecturer sometimes used MS PowerPoint to present or asked students to present optics topics The lecturer asked students questions	2. In the classes : Groups of students explained/presented optics topics to their classmates Students and lecturers asked questions to presenters Students asked lecturers questions The lecturer explained optics (Figure 2.8, Figure 4.5)
3. After classes: Students solved assignments	3. After classes: Students solved assignments (Figure 2.9, Figure 4.5) Students prepared for next class (Figure 2.8, Figure 2.9, Figure 4.5) Students' online discussion - Forum on LMS (Morning Group) (Figure 2.8, Figure 4.5)

Starting to Implement the CSI into Teaching Optics

The first optics class happened in the second week of the semester (the first week is for orientation) and was conducted over three hours. During these three hours, students studied continuously for two hours, had a short break of fifteen minutes and studied again for one hour. The three-hour-class covered the following optics content:

Topic one: Introduction

1. The Nature of Light

   [Three historical theories of light: Newton's particle theory of light, Huygens' wave theory of light and Einstein' theory - wave-particle duality on photons]

2. The Methods of Measuring the Speed of Light

   [Galileo's experiment and six methods of measuring the speed of light conducted by Røme, Bradley, Fizeau, Foucault, Michelson and Bergstrand]

Topic two: Interference

1. Fundamental Principles
2. Two-slit Interference (Young's Experiment)
3. Thin Film Interference
4. Application

Learning Activities Planned by the Lecturer:

For both Morning and Afternoon Groups:

- Students work in groups of five (fixed group for the whole semester). The groups had been formed on the first week.

- Each student was to read the two topics and to find learning material about the topics from the textbook, books and online.

  Designing this learning task, Mr. Van aimed to promote interaction between students-learning materials. He focused on ICT support for individual learning which was suggested by the CSI model. In Mr. Van's opinion, in order to understand the content of the two topics and prepare for the presentations, students interacted with learning material, including the learning material on the Internet; the learning material also supports individual learning processes and meaning-making of the students.

- The students were to have a group meeting to prepare for the presentations of the topics before the coming classes.

  Designing this learning task, Mr Van wanted to enhance interactions between students-students and students-learning materials. For him, the CSI model was implemented in terms of ICT support for the social aspect of learning processes.

- Students' presentations on the topics in class: To choose the student who would present, the lecturer randomly chose a group and within the group chose the student randomly.

  According to Mr Van, the goal of this learning activity was to foster interactions between students-students, students-teacher and students-learning material; ICT was used to support the social aspect of learning processes.

- Discussion on the topics, lecturer's summaries and explanation on the topic: the lecturer was to facilitate discussions in the class, summarise and provide students with further explanations on the optics content to help students gain insightful understandings of the topics.

Mr Van believed that these learning activities would promote students-students and students-teacher interactions; again, CSI model was implemented in term of ICT support for the social aspect of learning processes.

For the Morning group only

- The lecturer planned to remind the students of submitting the presentations to LMS and discussing on the forum of LMS.
- The lecturer planned to tell students: Next topic, students are going to submit their presentations on LMS by 12 p.m. every Friday.

Teaching and Learning Activities that Occurred in the Classes

The lecturer had planned well for the class. He had designed the learning tasks for the students so that they conducted some of the tasks before coming to the class, and others inside the class. While the above section presented the lecturer’s plan, this section will provide a detailed description of how the teaching and learning activities actually occurred in the optics classes.

In the Moring Class, it was planned by Mr Van that he would choose students presenting optics topics randomly from a group, and the group would also be chosen randomly. Nevertheless, in the real teaching practice, Mr Van allowed students to volunteer presenting topic one and two. The reason for the change of plan was that that day was the first day for students to present; the lecturer could sense that not many students were ready to present an optics topic in front of class. He wanted to encourage students, who had prepared carefully for the presentation and were willing to present as well as to show their work. This also gave the students who did not prepare well for the lessons opportunities to do better in the following weeks.

Topic one: Introduction

One student of Group 10 presented topic 1 via MS PowerPoint slides for about 15 minutes. The presentation mentioned different historical theories of light. The student also presented briefly different methods of measuring the speed of light which had been used in the history of physics.

In the slides, the student used different figures, diagrams and photos to demonstrate her ideas. Her presentation covered the content of the whole topic. The presenter sat on a chair while talking. Other students in the class listened to her; most of them could not see her face nor make eye-contact with her. Moreover, she did not ask any questions.

After the student presented, the lecturer invited the other four students in Group 10 to add information if they wanted. One student in the same group suggested the presenter should have explained in detail Foucault's method of measuring the speed of light. Another student suggested correcting the sign of different from "#" to "≠" in the slide "Particle Theory of Light" [to explain refraction, Newton had suggested that the perpendicular velocity of light in medium 1 (V1p) had differed from the perpendicular velocity of light in medium 2 (V2p): V1p≠V2p].

The lecturer then invited the class to give comments and ask questions. Only one student commented on an incorrect figure (year 1962 → year 1862) and the speed of light conducted by Røme.

The lecturer presented his feedback after the student completed the presentation: (1) The group had presented enough content of topic one; (2) The learning resources should have had references placed in the last slide of the presentation; (3) The presentation should have explained some facts about Newton, Huygens and Einstein who conducted three theories of light; (4) Because all students in the class were supposed to read the topic, instead of only explaining the content of the topic [‘lecturing’], the presenter should have raised questions; questioning and answering would make the learning environment more active.

Based on the presentation of Group 10, the lecturer explained topic one for about 40 minutes. He asked several questions, and a few students voluntarily answered the questions. The lecturer had to select students to stand up and answer; not many students gave the correct answer. The lecturer tried to interact with the students based on the learning resources: lecture notes and the MS PowerPoint presentation of Group 10.

Topic two: Interference

When Group 10 finished their presentation, the lecturer asked other groups to volunteer to present topic two, but no one volunteered. He checked all groups and found that no groups (except for Group 10) had prepared a presentation. One student of Group 10 (not the previous presenter) volunteered to present topic two.

While the students opened the MS PowerPoint file, the lecturer encouraged the students in the class to feel free to talk and contribute their ideas. The students in the presenting group were encouraged to feel free to add information after the presenter completed their presentation. The students presented for 10 minutes. She sat on a chair, read the slides and gave little explanation. The lecturer spent about

50 minutes asking questions and explaining topic two; he used the MS PowerPoint slides of the students when explaining topic two:

First, the lecturer facilitated the conversation on the interference of light via three questions: What is interference of light? Which theories should be used to explain interference of light? What is a wave? Based on the learning material, several students answered the questions. After the Q&A part of each question, the lecturer explained the answer to the students.

Then he suggested that the students should raise questions based on the presentation of Group 10; the questions should focus on what they did not understand after they had read the topic and listened to the presenter. After a short break of fifteen minutes, the lecturer invited Group 1 to ask questions.

The lecturer’s suggestion led to an interesting conversation between two groups. After discussing within Group 1, a student of the group questioned:

> A student of Group 1 (Student Q1.1): If someone has two similar torches shining the same place, will she get the interference?
>
> **[**The lecturer gave priority to the presenting group (Group 10) to answer first, then other groups]
>
> A student of Group 10 (Student A10): The interference will happen.
>
> Another student of Group 1 (Student Q1.2): If you let two torches shine the place on the wall, can you see the inference of light on the wall. Will the light density in this case differ from the case one torch shines?
>
> Student A10: In a dark room, the density of the torchlight of one torch will differ from the density of the torchlight of two torches; therefore, I believe the interference will happen.
>
> Student Q1.2: Are you sure that the interference will occur? Is this what you think? Which theory do you base on to think that the interference will occur?

> [Student A10 could not answer the question properly]
>
> [After the question of student Q1.2, many students opened their lecture notes to find the answer for the question.]
>
> [The lecturer invited a student from other groups]
>
> Student A.1: That the lights from two torches have the same intensities does not mean they are coherent; therefore, the interference will not occur.
>
> Lecturer: Other students?
>
> [No student answers]
>
> Lecturer: To explain optical interference, we need three important foundations: Huygens' Principle, the principle of superposition and coherence.

After that, the lecturer explained topic two and used some slides from the student's presentation. At the end of the period, the lecturer assigned homework: solve the problems of topic two (which are available in the lecture notes) and prepare for the presentation of topic three.

What happened in the class of the Afternoon Group was similar to those of the Morning Group. The class also lasted 3 hours and covered the same content. The lecture teaching strategy was quite the same. At this stage, the learning management system LMS had not been used by both groups to support their study.

However, students in the Morning Group had been requested by the lecturer to register to the Optics Course on the LMS and get familiar with the LMS. The students of the Morning Group were also requested to submit the PP slides and share learning resources on LMS the week after (week 3). The students of the Afternoon Group were not requested to use the LMS at all.

The above description shows a snapshot of the very beginning of the CSI Model implementation where the students needed more support from the lecturer; and the lecturer was scaffolding his students. The interaction between students – students was quite low in the first optics classes. The students in both Morning and Afternoon Groups generally did not invest enough time to conduct the given learning tasks at the beginning of the semester.

5.2 Findings from Qualitative Data: Interviews with the Lecturer, the Teaching Assistant and Students

After the CSI Model was applied into the Optics Course teaching practice for a semester, this implementation had some influences on students' learning. To understand more about the students' and the lecturer's experiences on the use of the model, data was collected from the lecturer, the teaching assistant and students in the form of interviews. This section will provide findings from the interviews - a few glimpses of the CSI Model's impact through the lecturer's, the teaching assistant's and students' reflections.

5.2.1 Interviews with the Lecturer and the Teaching Assistant

Interviews were conducted with the lecturer - Mr Van, and the teaching assistant – Mr. Phong. There were two lecturer interviews: an interview was conducted at week four of the semester, another was conducted at the end of the semester. The teaching assistant observed almost every optics class during the semester, learned how to teach this subject from Mr Van but did not conduct any tutorials. A quick interview with him on the Optics Course's teaching practice was also obtained and analysed.

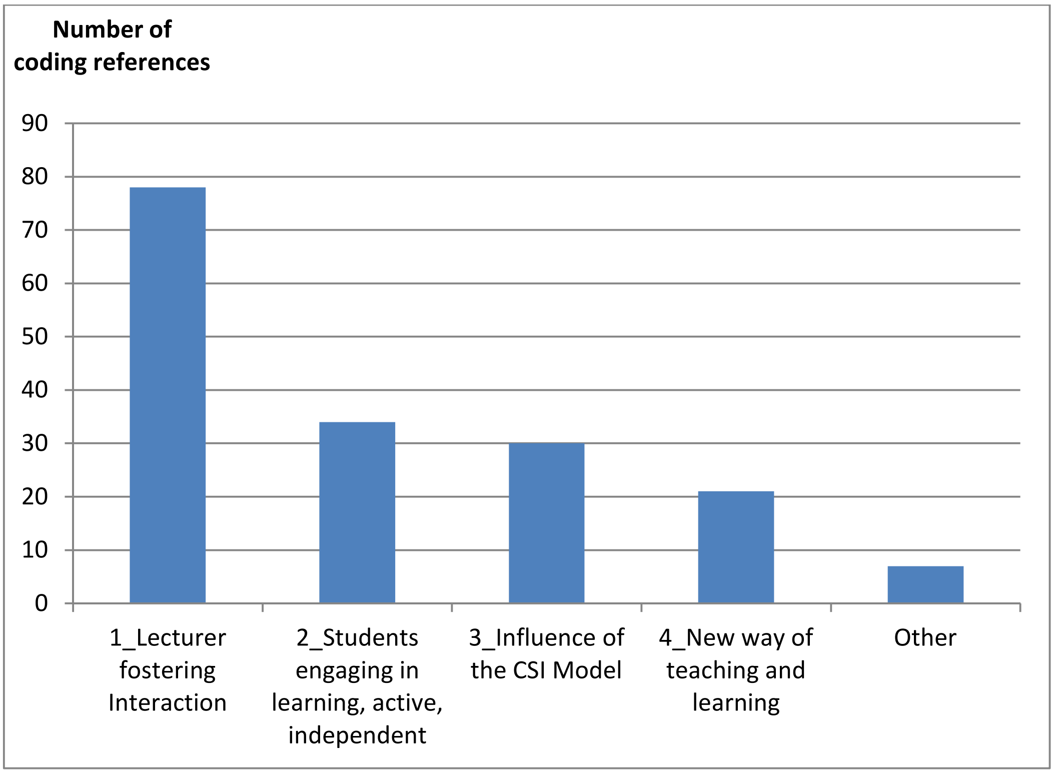


Figure 5.1 Themes coded from interviews with the lecturer and the teaching assistant

Figure 5.1 presents the themes, which were coded from the interviews with the lecturer and the teaching assistant, and the numbers of references coded in each theme. Four main themes emerged from the lecturer's and the teaching assistant's interviews: (1) the lecturer fostering interaction within the learning environment, (2) students engaging in learning, (3) influence of the CSI Model, and (4) a new way of teaching and learning. The following section will discuss these four main themes and then a summary will be presented.

5.2.1.1 The Lecturer Fostering Interaction within the Learning Environment

Findings from the interviews with the lecturer and the teaching assistant revealed that the lecturer focused on fostering interaction within the learning environment when he organised learning activities for the students. Mr Van stated that he focussed more on enhancing interaction both inside and outside the classrooms in this semester than he did last semesters.

Outside the classes, data from the interviews showed that Mr Van assigned learning tasks for the students: working in groups, searching for information from different resources such as online sources, the textbook and books, and designing MS PowerPoint presentations to explain the optics topics to their classmates. He also asked the Morning Group students to submit their presentation slides on the online learning management system - LMS and write their discussion on optics topics on the LMS. One of his aims when designing these learning tasks was to enhance interaction between students and students as well as students and learning resources. According to Mr Phong, the teaching assistant, in this semester, Mr Van had required his students to conduct learning tasks every week – presenting and explaining optics to their peers; thus, this-year-students worked harder than last-year-students.

> [This year] the students were asked to do presentations every week. They had to read the material and do assignments. Last year, students did not work hard and prepare well for the lessons. (Mr Phong)

Inside the classes, it was revealed from the interviews that Mr Van asked students to present and explain the optics topics to their classmates. Furthermore, he tried to engage the students in discussions on the topics and helped them acquire deep understandings of optics. The lecturer said that the students were engaged in the learning activities.

> I increased students' learning activities at home for lesson preparation. In class, when I raised an issue, students became

> engaged quite well in discussion. Students also actively took part in the online learning system. (Mr Van)

In an interview, the lecturer also explained how he facilitated a discussion to help the students understand thoroughly *the Fresnel Zone Method* which was a section of *Topic 3: Diffraction*. This optics content had been explained by one group of students using PowerPoint slides. After the group’s explanation, Mr Van utilised a series of questions to lead the discussion with the whole class. The content of one question was based on students’ answers to the previous question. It was believed by the lecturer that at the end of this discussion, the students could make sense of *the Fresnel Zone Method*. Mr Van recounted:

> For example, the hole is big. It is big enough that we can divide one sphere into annular regions [ring-shaped zones] [Fresnel zone].
>
> I asked them 'what is the amplitude of the ring-shaped zone number n compared with other ring-shaped zones?'
>
> They said that 'much smaller' and I said 'it is not correct. They are all the same. When the ring-shaped zones propagate the light wave to the point M, at the point M, the amplitudes will be different.
>
> [Lecturer:] ‘For example, if there are 10 ring-shaped zones sending light waves to M, so M receives 10 light waves. Are the ten light wave functions the same?'
>
> At that time, a student said that 'they are not the same'.
>
> [Lecturer:] ‘why?’
>
> Then the student said 'because of the distance'.
>
> And then they understand about the amplitudes of the light waves at the annular regions [ring-shaped zones].
>
> When students use the equation [a = a1/1 +- an/2], I asked 'where do you get the equation?' ... Students who understood answer 'it is from Fresnel Zone method'. We need to help students get the key point there.

5.2.1.2 Students Engaged in Learning, Became More Active and Independent

The lecturer and the teaching assistant believed that the implementation of the CSI Model enhanced the students' learning; the students became engaged in optics learning, more dynamic and active, and more skilful at presenting and explaining optics during the semester. Mr Van stated: "The students were engaged in the learning activities in the classes well." They searched for information, studied and prepared for the optics lessons and presentations. The lecturer commented:

> This week is the fourth week. From my observation, there have been positive changes. The students gained knowledge when they prepared for the lessons or carried out the tasks the lecturer required… It was quite successful.

The learning activities did not only occur inside the classroom but also outside the classroom. The resources the students used were not only the textbook as they did the previous year but also online resources. They were motivated and wanted to learn more about the subject. Besides becoming more dynamic and active in searching for information and preparing for the optics presentations, the students also became more active in classes. Mr Phong - the teaching assistant – noted:

> The students made progress. They asked questions on the topics that they did not understand. I have a feeling that they want to understand more about this subject [Optics].

The students' skills on presenting and explaining optics topics also enhanced. At the beginning of the course, the students just read from the PowerPoint slide. But later, during the course, they introduced and explained the lessons and assignments.

> There have been changes in the way the students present. Instead of reading, as I observed previously, they just read. Now, they have

> had introduction and explained to other students. They explained clearly their assignments. Regarding their presentations of the lessons, they explained the sections they understood. And there were points they did not understand, they said that they did not understand and asked the lecturer to explain for them. (Mr Phong)

At the beginning, the students were quite shy, afraid of talking and asking questions. Gradually, they started to ask questions, became more confident in talking, asking questions of their peers and even asked the lecturer to explain sections they did not understand.

> I am happy. I feel that the presenting students wanted their friends to ask them questions. It is not the same like before, they had been afraid of being questioned and afraid of not knowing how to answer the questions. Now after each section, they stopped and asked: 'Do you have any comment or questions? This is because we guide them. (Mr Phong)

5.2.1.3 Influence of the CSI Model

The lecturer believed that at the time the interview occurred – week four of the semester, the students, who experienced the implementation of the CSI model, were more engaged in learning than last-year-students had been. In his opinion, at the beginning of the semester, the levels of the students' engagement in learning in both years were similar. He also believed that the students experiencing the CSI-model-implementation became more active and independent learners.

The lecturer considered that the key factor that made a difference between the current and the previous semesters' teaching was the use of ICT and the CSI Model focussing on supporting students' learning and interaction. Implementing the CSI into his teaching practice, the lecturer was more conscious on the pedagogic aspect while using ICT in teaching than he had been last semester. He especially focussed on using ICT as a tool to enhance the interaction between teacher-students, students- students, students-learning material and to foster students' learning.

> On the request of your research, I focus more on interaction. That is the first point. The second point is that at some extent, I did not focus on learning activities of students [the previous year]. The students themselves were ... we may say ... passive [not active in learning]. If we try to stimulate them, they will work actively according to our goal. (Mr Van)
>
> Thanks to your intervention, the students' learning activities are increased both inside and outside classroom, students' preparation at home and online. Students are stimulated and inspired in learning. (Mr Van)

5.2.1.4 A New Way of Teaching and Learning

Teaching

The interview data also revealed that the implementation of the model provided opportunities for a new way of teaching and learning. In the aspect of teaching**,** because of the requirement of the research (implementing the CSI model into teaching practice), the lecturer focused more on creating learning tasks for students and tried to increase the level of interaction within the learning environment. Mr Van revealed:

> There are different factors which influence students' learning activities such as lecturers, the number of students in class and the nature of students (e.g. active or passive). The most vital factor is lecturers who engage students in learning activities of groups by different ways. This year, I change the strategy to organise the course by focussing more on students learning.

With this new way of teaching, the lecturer noted the changes in his students:

> If the lecturer tries to activate them, they will be much better. Therefore, for the last few weeks, I have not lectured the

> knowledge of the topics, but asked the students to design the presentations of the topics. Now the students' engagements in learning have improved gradually. A majority of students read the learning materials before going to class... The students of the last year groups did not read the materials as much as these groups.

In Mr Van's opinion, his teaching practice in the last-year-optics course was different:

> Last year, I did not focus on the learning activities of the students.

According to the lecturer, he became more 'pedagogic' in the use of ICT this year. Mr Van said that last year he asked each group of students to present one topic. After that, he lectured the content of the topic. From his observation, only the group who had been appointed to present a topic really learned the topic; the others did not. The students who did not belong to the presenting groups did not read learning material that he had given. Many students did not understand the optics knowledge and did not do the assignments he had given. Hence, the last-year students did not do well in the optics examination.

Mr Van indicated that, this year, based on the model, he focused more on the students' use of ICT to support their learning. He tried to encourage the interaction between students-learning material, students-students and students-lecturer by giving the students learning tasks, checking them and motivating them. The lecturer designed learning tasks with the requirements that the students needed to search and study different learning resources, and design a group presentation on optics topics. By this way, Mr Van believed that he had created opportunities for the students to interact with learning resources, work in groups and discuss. The lecturer requested the students to explain optics to their peers and encouraged discussions in classes. His teaching appeared to move from more teacher-centred to more student-centred teaching practice in which teachers guided and facilitated students' learning. Mr Van smiled and said:

> I am not teaching this year. The students present the topics.

Learning

In the aspect of learning, the lecturer revealed that this way of learning was also new for students. "It is new for the students. They never did something like this before. Now the lecturer requests them." said Mr Van.

He explained that it was because of the requirement of the lecturer; the students used the MS PowerPoint in their presentation. According to the lecturer, for most of the students, this was the first time they presented content of a course and used MS PowerPoint. Although the students were not skilful in using MS PowerPoint for presenting, they exploited the software in the aspect of presenting information. For example, besides the content, diagrams and photos related to optics, the students showed the photos of scientists and their biographies. They looked for online learning resources by themselves besides traditional resources.

Mr Van mentioned that he told the students that they had to be responsible for their own learning; and if they did not understand, they needed to ask. This statement was reflected in the classes. Mr Van requested the students to ask the presenting group questions in order to get more information and understand presented topics. The questions were also to help the presenting group to clarify and elaborate on their explanation. If the audience students did not ask the presenters, the lecturer would question both audiences and presenters. He believed that this would make the students concentrate on and brainstorm the optics topics.

5.2.1.5 Summary

Mr Van concluded the CSI model "Is a suitable pedagogic model for University A [name of his university] in particular and for Vietnam in general… It is very useful for teaching practice where ICT is implemented". He stated that "this is a good tool to support for students' active learning and students' researching by themselves" and "it was necessary to spread and make the CSI Model become known by young lecturers and train them so that this model will be empowered by teaching practices". "It is necessary to have policies to enhance teaching using the pedagogic CSI Model" said the lecturer.

Besides the positive feedback on the model, Mr Van also cautioned lecturers and teachers who will implement it: "At the early steps… lecturers and teachers need to be patient and persevering in influencing students and creating a learning habit for them".

Mr Van's limitation in implementing the CSI Model, as he pointed out, was the knowledge of ICT. He said that it was really hard for him to catch up with the young generation of students. From his points of view, he could not handle ICT well, but students could; therefore, he created learning tasks and forced students to use ICT to support their own learning.

From Mr Van's perspective, the CSI model is a useful model to support students' learning. The following section will disclose the students' perspective on the model implementation.

5.2.2 Interviews with students

Un-structured interviews with groups of students were conducted mainly at the end of the semester. Of about 90 students who participated in this research, 36 students were interviewed. The themes and the number of references, which were coded from students' interviews, are presented in *Figure 5.2*. The data from these interviews disclosed that students' reflection on their experience of the implementation of the CSI model focused on five main themes: (1) the good way of teaching in the Optics Course, (2) interaction, (3) enhance physics learning, (4) ICT support learning and (5) weaknesses. This section will discuss the five themes in the above order and the students' comments related to the themes.

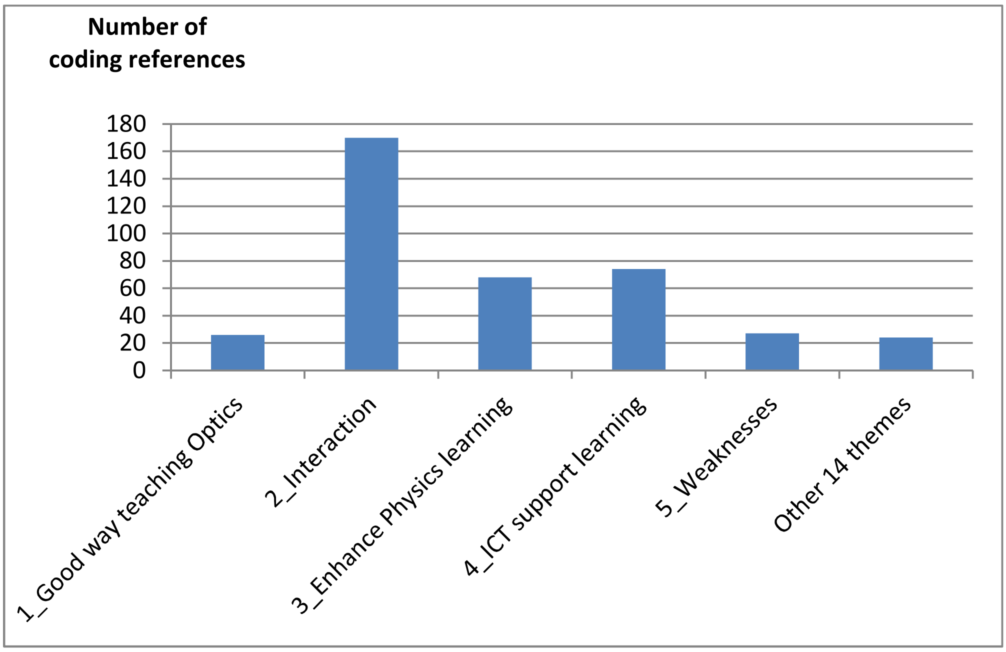


Figure 5.2 Themes coded from interviews with students

5.2.2.1 A Good Way of Teaching in the Optics Course

According to the students participating in the research, they appreciated the way of teaching the optics, and this was a suitable teaching model. The students said that they were given opportunities to research optics topics; and this made the Optics Course different from other courses.

> For me, this way of teaching is very good... I think that the way that the lecturer asks us to present optics topics is excellent because we

> can research the topics at home before going to the class. (SI_MGW15 (Student interview _ Morning Group _ Week 15))
>
> It is a suitable model of teaching… The time that we need to do research by ourselves is more than the time that lecturers teach us, in comparing with other courses. (SI_MGW14)

The interviewed students indicated that this learning environment was comfortable, relaxing, enjoyable, surprising and fun; studying in this optics classes was more exciting than other classes:

> It [The learning environment] is relaxing, joyful and easily comprehensible. (SI_AGW14 (Student interview _ Afternoon Group _ Week 14))
>
> In the lectures of other courses, the teachers give lectures, the students listen. Therefore, the atmosphere was not as exciting as in the optics class. (SI_MGW15)

The lecturer was considered by the students friendly and enthusiastic:

> I am comfortable… because the lecturer is friendly with me. (SI_AGW15)
>
> We heard that Mr Van is difficult. But when we study, we find that he is fun. (SI_AGW14)

One student even got the feeling that Mr Van appeared as an uncle:

> This course is very friendly. In class, I have the feeling the teacher is like a father or an uncle. The feeling is different from feeling in the other courses I have taken. (SI_AGW14)

5.2.2.2 Interaction

Data from the students' interviews revealed that the Optics Course was more interactive than other courses. The interviewed students described:

> I think the interaction between teacher and students in this Optics Course is more interactive than other courses that I have studied. It is because in the other courses, the lecturers talked most of the time,

> and the students listened and hardly had opportunities to talk or present our ideas. (SI_AGW15)
>
> The lecturer teaches us more enthusiastically and clearly than other lecturers did. This helps students internalise lessons faster. The material from other students helps me understand lessons more clearly. (SI_AGW15)

In addition, the degree of interactions with the learning environment of the Optics Course also increased during the semester:

> I see the classroom is more fun and my classmates talk and contribute to the lessons more actively than they did at the beginning of the semester. (SI_AGW15)

The interactions within this learning environment can be divided into three types: students-students interaction, students-learning material interaction and students-teacher interaction. From the analysis of the students' interviews, themes related to how these types of interaction occurred within the learning environment emerged. The following sections will narrate students' stories through the emerging themes and types of interaction.

Students – Students interaction

Student interview data showed that there was a wide range of ways the students interacted with each other in this Optics Course. For example, they worked in groups outside class, discussed and carried out learning tasks. They shared the work load among group members in order to complete their learning tasks. Other examples of students-students interaction are in class discussion, exchanging ideas and solutions for assignments, explaining optics topics to their peers and online discussions.

The students said that they were given learning tasks, for example preparing presentations to explain optics topics to their classmates. The students met each other outside the class. They worked in groups and had group-discussions to prepare for the presentations.

> It is because the lecturer ask us to prepare the presentations in group, we discuss [with each other]. For other courses, we don't need to prepare presentations and work in group. So we don't discuss. (SI_AGW14)

> For group working and discussing, students go to empty classes, not the library because they should not make noise in libraries. (SI_AGW14)

The students also noted that "We share the workload of the topic". For example, their group was going to present a topic of optics. The topic contained ten optics lessons. There were five students in the group. The group members decided each person should find information, research on two optics lessons. Then a member of the group combined the work of the whole group.

> [We divide the workload] equally. For example, if the topic has 10 lessons, our group have 5 members; each of us will have 2 lessons. Then there is a person to combine the work. It is similar for assignments. We divide the assignments equally among us. (SI_AGW14)

> We need to read learning material carefully, divide the work among group members, research about the topic, typing in MS Word and design the presentation on PowerPoint. (SI_MGW14)

In class, the students also explained optics topics and solutions for assignments to their peers. They asked questions, discussed and shared ideas. By this way, the students thought that they saved time for studying and understood optics more in-depth.

> The second strong point is assignments. Each group explains an assignment. This helps to save time. We have many groups; so we can discuss the assignments. If we don't understand an assignment, we will exchange and discuss... If a group doesn't know [how to solve an assignment] they can ask other groups. (SI_MGW14)

> I work on the presentation one time, then listen to the presentation of classmates one time and listen to the explanation of the teacher once more. Therefore, the optics knowledge is more in-depth compared with other courses. (SI_AGW15)

Students – Learning Material Interaction

According to the students, by working on the learning tasks given by the lecturer (e.g. prepare for the presentation of each topic), they needed to do lots of reading and researching; by this way they could learn more:

> The lecturer requires us to prepare a presentation for each topic. This helps us learn more and learn all of the content. (SI_AGW7)

> Reading material before going to the class is very good. (SI_AGW14)

A student explained how reading in advance helped her learn new topics:

> I believe that we prepare for the lesson at home as we did. We read in advance. We then go to classes, the teacher explained to us. It is easier for us to understand [the lesson] and remember it than when we go to classes with a blank head. If we go to class without reading in advance, when the teacher lectures, it is hard for us to understand and remember the lesson. When we read [learning materials] at home, we know which parts we understand, and which parts we don't. In class we concentrate more on the parts we don't understand. For the parts we have understood, we can ignore them. If we don't read [learning materials] in advance, we listen to the lecturer steadily. This is not that good [as reading in advance]. (SI_AGW14)

The students studied the lecture notes, read books, found information online and researched the optics topics. It is noted that the students did not depend solely on one source of information (e.g. books or lecture notes), but they combined different sources which could help them make sense of optics content.

> [I] go to a physics web page, read and research the content. [I] read and find something related to the lecture notes and something the lecture notes do not explain clearly, [I] look for it and read it. (SI_AGW14)

Students – Teacher interaction

The students felt that the degree of students-teacher interaction was high in the Optics Class. The students stated that they had more opportunities to discuss with this lecturer in comparison with other courses. The lecturer usually asked questions in class. The purpose of these questions was to guide the students in the class to think and explain the optics topics to their peers. The students contributed to the discussion in the class and so co-constructed their knowledge on the topics. If the lecturer felt that the topics were not fully explained by the students, then he would provide further explanations.

> I like [the course] because I have more opportunities to discuss with the lecturer... (SI_AGW14)
>
> In class, the lecturer usually asks questions and discuss with us.(SI_AGW14)
>
> The teacher asked students questions to help students understand the topic until they could not explain to each other, he would explain. Not like other teachers. (SI_MGW14)

The students also stated that the lecturer created opportunities for the students to interact with online learning resources. He also provided the students with learning environment, both face-to-face and online, in which the students were encouraged to exchange and present their ideas, and actively participate in the lessons.

> The teacher lets us comfortably exchange ideas and look for online resources. I think this helps us enrich our knowledge. (SI_AGW15)
>
> The lecturer lets us doing research on each topic at home. Then we discuss in class. (SI_AGW15)
>
> When we have questions, we send the questions to LMS. The teachers then answer us clearly and in detail whenever they have time. (SI_MGW15)

5.2.2.3 Enhance Physics Learning

The students felt that this new way of teaching helped to enhance their physics learning. According to the interviewed students, this way of teaching engaged them more in learning, helped them comprehend the physics lessons faster, had a better understanding and became more active, dynamic and independent learners.

Findings from the students' focus group interviews showed that the students attending the Optics Course were deeply engaged in learning. The students had read learning resources and researched on optics lessons before they went to the class and learned the lessons. They invested much time to study optics at home:

> To prepare for a presentation, it required hard work. We need to read learning material carefully, divide the work among group members, research about the topic, typing in MS Word and design the presentation on PowerPoint. It takes a lot of time to do a presentation. (SI_MGW14)
>
> I believe that we prepare for the lesson at home as we did; we read in advance; we then go to classes, the teacher explains to us; it is easy for us to understand. (SI_AGW14)

Students' engagement in learning was also reflected in the way the students studied new optics knowledge:

> During the process of making the presentations, besides lecture notes, I need to use other books and learning resources. For example, there are difficult terms or definitions; I have to study

> different learning resources to find explanations and definitions which are easy to understand for other students. (SI_MGW15)

The students stated that they comprehended physics lessons faster, more easily and better with this way of teaching. According to the students, the applications of ICT such as computers, LCD projectors, videos and photos attract their attention and help them to comprehend optics faster and more easily.

> The role of computer in learning is very important. It is because when the lecturer uses LCD projectors to present, images and photos are more vivid. It is easier for students to comprehend [knowledge]. (SI_AGW15)

> Interactions in this Optics Course is better than the other courses. The lecturer teaches us more enthusiastically and clearly than other lecturers did. This helps students internalise lessons faster. Through the material from other students, I can understand lessons better. (SI_AGW15)

This way of teaching also helped the students obtain in-depth understandings and enrich their optics knowledge:

> In my opinion, when I study this optics course, my knowledge is more explicit than my knowledge from other courses. First, I work on my presentation one time, then listen to a presentation of a classmate one time and listen to the explanation of the teacher once more. Therefore, the optics knowledge is more in-depth compared with other courses. In addition, the teacher lets us comfortably exchange our ideas and look for online resources. I think this helps us enrich our knowledge. (SI_AGW15)

The students said that they became more active in learning and understand the topics more deeply. From the students' point of view, with the lecturer support, they became more active in learning. According to the students, the lecturer gave the students learning tasks to work on at home. They conducted the tasks and actively studied the optics knowledge. The lecturer asked the students to explain the optics topics to their classmates. This required them to work hard and try to understand the knowledge as deeply as they could so that they could explain the topics in class.

> When the lecturer gives us tasks, we will understand specific work to do at home. We become more active in studying knowledge. When we want to stand in front of our classmates to talk, we need to understand the knowledge deeply and in details so that we can talk. (SI_MGW14)

Moreover, the students indicated that comparing the class at the beginning of the semester to the classes which occurred later in the semester, their classmates contributed to the lessons more actively; the learning environment was more fun. They became more dynamic and volunteered to solve assignments.

> I see the classroom is more fun and my classmates talk and contribute to lessons more actively than they did at the beginning of the semester…For me, my classmates become dynamic and volunteered to solve assignments. (SI_AGW15)

The students also stated that they were trained during the Optics Course and became more independent in learning. The lecturer required students to research on the optics topics and provided them guidance. From this, students learned to find learning resources, to study a topic, to present a topic and to discuss in class. The students said that they played the role of a lecturer.

> For the Optics Course of this semester, from my observation, there is a great difference between this Optics Course and other course. The lecturer lets us do research on each topic at home. Then we discuss in class. Students play roles of lecturers. (SI_MGW14)

A student compared the ways of teaching which she had experienced at a high school and the way this Optics Course was conducted. In this course, the lecturer did not teach her in a traditional way but guided her to find knowledge. The student believed that this way of teaching helped her become more independent in learning. It would be also very useful for her career in the future – a high school teacher.

> In my opinion, the teaching way at high schools is that teachers held our hands and led us walking [spoon feeding]. But here [at universities], the lecturer shows us directions to go. Our major is education. If the lecturer keeps holding our hands and leads us all the time, we will get used to this habit. When we graduate from universities, we become people who hold other people's [students] hand and lead them walking. We get used to this habit and we cannot guide students. Therefore, I believe that the lecturer showing us directions is good. It is because this trains us to be independent. We know how to find learning resources by ourselves. When we graduate from universities and teach at schools, the lecturer will not be around to show us where the resources are. We need to find out ourselves. It is good to train us to become independent since we study at universities. It is suitable for education major and other majors as well. (SI_AGW14)

The interviewed students believed that this way of teaching helped them develop necessary skills for learning including skills of working with computers, seeking information, presenting and explaining ideas.

> I believe that when I study this course, I have developed skills such as the skill of talking in public, skill of working with computers and find information online. (SI_AGW15)

> Learning this course, I become more dynamic and learnt how to present the idea I wanted to say. (SI_MGW15)

5.2.2.4 ICT Support Learning

Student interview data revealed that ICT played an important role in supporting students' learning. Students' applications of ICT into learning could be categorised into (1) ICT promoting social interaction and (2) ICT supporting individual learning.

ICT Promoting Social Interaction

The students used ICT to support face-to-face presentations. From these students' point of view, using ICT (e.g. images, photos and videos clips) helped to attract their classmates' attention and help learning become enjoyable:

> When teaching with ICT, we have photos and video clips. This attracts students' attention. (SI_AGW15)
>
> PowerPoint presentations help students study more easily, help reviewing lessons become relaxing and enjoyably, make learning more surprising and exciting. (SI_AGW15)

In addition to face-to-face discussion, the students found that online discussion was also useful. For students, they could discuss in detail, see and hear the phenomena. The students could also instantly look for online learning resources to support the discussion.

> When we need to discuss in details, we cannot discuss by phone calls or messages. Discussing via phone limits us for observing details of phenomena…. We can see, hear and discuss synchronously via the internet. While we are discussing if my friends feel that they do not satisfy with one section or this section is not quite accurate, my friends can instantly look for different learning resources on the internet. (SI_MGW15)

ICT Supporting Individual Learning

Data from the students' interviews also disclosed that the students predominantly used ICT as a tool to help them look for learning resources:

> The Optics Course in this semester requires us to find information. Naturally, we need computers. For example, for assignments and models, we need to search them online. (SI_AGW14)

The students noted that as a requirement of the Optics Course, they needed to search for optics information online. Google was considered by the students as a useful tool for searching for information. The students said that optics information on this search engine was rich and diverse, and to deal with the information, the students disclosed that they needed to analyse and compare the optics information.

> If I want to research about something, I just go online and 'google'. (SI_MGW14)
>
> Another advantage is that information on Google is very diverse and rich. For example, when we look for specific information on Google, related information also appear below the needed link [that connects to the specific information]. We can find the related information; the text books don't have such advantages. There are different sources so that we can compare and reflect. (SI_MGW14)

The articles listed on the Learning Management System were also highly appreciated by the students because the articles were from different authors and different sources. In addition, the articles also contained information which was not available from the textbook.

> One of the strong points of the e-learning system is that teachers post articles from different authors relating to each topic. Some knowledge in the articles is not available in the textbook. So we can research more from the articles of different authors and different places [website] to search for information. (SI_MGW14)

ICT was utilised by the students as a useful tool to acquire information. Besides this, the students commented that the use of ICT supported internalising and remembering knowledge:

> Using ICT to teach helps students to internalise [knowledge] more easily because when teaching without ICT, it is dry and boring. (SI_AGW15)
>
> There are some issues we cannot remember, but when seeing the pictures on the screen, we can remember. (SI_AGW15)

5.2.2.5 Weaknesses

Data analysis from the students' interviews showed that there were three main weaknesses of the Optics Course in the students' view: time consuming, students' unclear explanation in optics and technology barriers. Some students complained that it took them a lot of time to study optics. One student said that he took many courses at the same time so he did not have enough time to study other courses while investing much time on optics.

> For me, this way of teaching is very good. But for me, now I study too many courses at the same time, and time is important for me. And the time which I spend on studying optics occupies majority of my time. I don't have enough time to study other courses. (SI_MGW15)

While some students considered investing much time in studying optics outside the class was a weakness, a majority of them thought it was a strong point:

> For me, this way of teaching is very good. (SI_MGW15)

> Preparing for lessons before going to class depends on ... one is hard-working or not. Some people like [this way], some people do not like. It requires hard-working characteristic of people. Reading material before going to class is very good. (SI_AGW14)

A few students liked lectures only and felt uncomfortable with the current way of teaching. For them, it was easier to comprehend the knowledge when the lecturer explained optics; the knowledge that the lecturer presented was absolutely correct while the knowledge they discovered themselves might not be correct.

> Another group presented the topics and I cannot understand. I like us to prepare for lessons before coming to classes, and the lecturer gives lectures in classes. It is because when he lectures, it is easier for me to comprehend. (SI_MGW15)

> But what we discover by ourselves [optics knowledge] is not surely correct. Only the knowledge that teachers providing us are absolutely correct. (SI_MGW15)

In contrast, a majority of the interviewed students liked this new way of teaching: the students researched on the optics topics in advance and explained the topics in class; the lecturer facilitated discussion and explained in detail the topics when it was necessary.

A small number of students indicated that they could not identify the key content to prepare for tests and an exam. In these students' opinion, while lecturing, the lecturer could skip un-important content.

> Studying by this way, I don't know what the foci of content are so that I can review the lessons to prepare for tests and final exam. (SI_MGW15)

> But we designed the presentation before the lecture so we cannot identify which part is the key content. It is not as good as the teacher lectures us directly; for un-important parts, the teacher can skip. For us, we just type every optics content. I don't know where the main content is so we make our effort to think about all the content [of the lesson], not focusing on a particular part. (SI_AGW14)

Other students described that they identified the important content by following the lecturer's explanation: the lecturer explained the important content more carefully; for the un-important parts, the lecturer will talk briefly about the parts.

> For example, when we were having presentations, we presented in a steady pace. In some part, the teacher actively started to talk and explained more. Then we knew this part is more important than other parts. When the teacher talked briefly about some parts, we knew that those parts were not important. (SI_AGW15)

From the students' points of view, another weakness of the teaching of the Optics Course was technology barriers. Although the university provided students with computers in the labs and libraries, it was not convenient for students who did not have their own computers to work on the learning tasks and attend the discussion online.

> For students who have computers at home, they can go to LMS regularly. I do not have a computer, so I use the university's computers. There were questions to discuss but I missed it because I have not access the internet for more than one week. (SI_MGW14)

> About 50% of the students in this class don't have laptops or desktop computers at home. So it is difficult to prepare for the PP presentation. Students who have computers at home work hard and work on Optics for four or five days a week. Students who don't have computer at home… don't prepare the presentations. So there is a big gap between students who work and who don't work. And… they are in the same group. (SI_AGW14)

In addition, from the students' point of view, the quality of the university Wi-Fi system was not as good as the students expected. This also added more inconvenience for them. Few students challenged this point of view; they thought that the classmates used these technology barriers as excuses/fake arguments for not working hard on the learning tasks.

5.3 Findings from Quantitative Data

As mentioned in *Chapter three – Research Methodology*, this research employed mixed methods. The quantitative data was the main source of data to examine the impact of the CSI Model. The qualitative data was to support and triangulate the quantitative data. The findings from the qualitative data sources such as the description of the implementation of the CSI Model and interviews with the lecturer, the tutor and the students were presented in the above sections. The quantitative data included the data from the optics tests, the critical thinking skills tests, the observation scheme and the students' questionnaires. This section will explain the findings from these four sources of quantitative data.

5.3.1 Interaction within the Learning Environment

5.3.1.1 Observation Scheme

Observations were conducted in the optics classes by two observers working at the same time. Each observer conducted two observations. One observation was at the beginning, and the other is at the end of the semester. Two observers were trained to do the observations, use observation schemes (*Figure 5.3*) and scored the degree of interaction in the scale of 1 to 10 (*Figure 5.4*). The observations are considered reliable and so included in the data if the inter-rater reliability of this period is equal to or larger than 90%. The inter-rater reliability of each period was calculated as:

$$\frac{number\ of\ cells\ two\ observers\ agree}{total\ number\ of\ cells\ in\ observation\ scheme\ of\ 1\ period}\ x\ 100\%$$

The calculation inter-rater reliability of one period conducted in week 2 in a class of the Afternoon Group is presented as an example of how to compute the reliability. There are 18 cells per one observation sheet which contain the 18 observers' scores on the degree of interaction (*Figure 5.4*), and 4 sheets were used in one period. Thus total number of cells in one period is:

$$Total\ number\ of\ cells\ in\ one\ period = 18\ cells\ x\ 4\ sheets = 72\ cells$$

The number of cells the two observers agreed in this period was 69

Therefore:

$$Inter - rater\ reliability =$$

$$\frac{number\ of\ cells\ two\ observers\ agree}{total\ number\ of\ cells\ in\ observation\ scheme\ of\ 1\ period}\ x\ 100\%$$

$$Inter - rater\ reliability = \frac{69}{72} \times 100\% = 95.8\%$$

Because the reliability of 95.8% is greater than 90%, the observations occurred in this period is used for data analysis and account for research findings. When observations of a period meet the condition that inter-rater reliability is greater than 90%, the average scores of the two observers' score are calculated. These average scores become the input for t-tests which (1) compare the interaction degrees in the class at the beginning of the semester to those at the end of the semester and (2) compare the Interaction Degree between the Morning Group and the Afternoon Group.

The Observation Scheme **Week ………** **Group ……..**

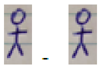
For Recording Interaction within Learning Environment

Date: ……………………. Time: ………………. Location …………. Period No.: ………….

Observer's name: ………………………………………

Observation 1: minute 10th- 15th

1 cell

Timeline / Interaction between	1st 60s	2nd 60s	3rd 60s	4th 60s	5th 60s	6th 60s	Note
 [student(s) – student (s)]							
 [teacher – student (s)]							
 [student(s) – learning material(s)]							
Task							
Task in hand							
Previous task							
Future task							
Non-task							

The degree of interaction: Scale of 10

	10	9	8	7	6	5	4	3	2	1	0	
Very highly interactive	_	_	_	_	_	_	_	_	_	_	_	Not interactive at all

Figure 5.3 One sheet of an observation scheme

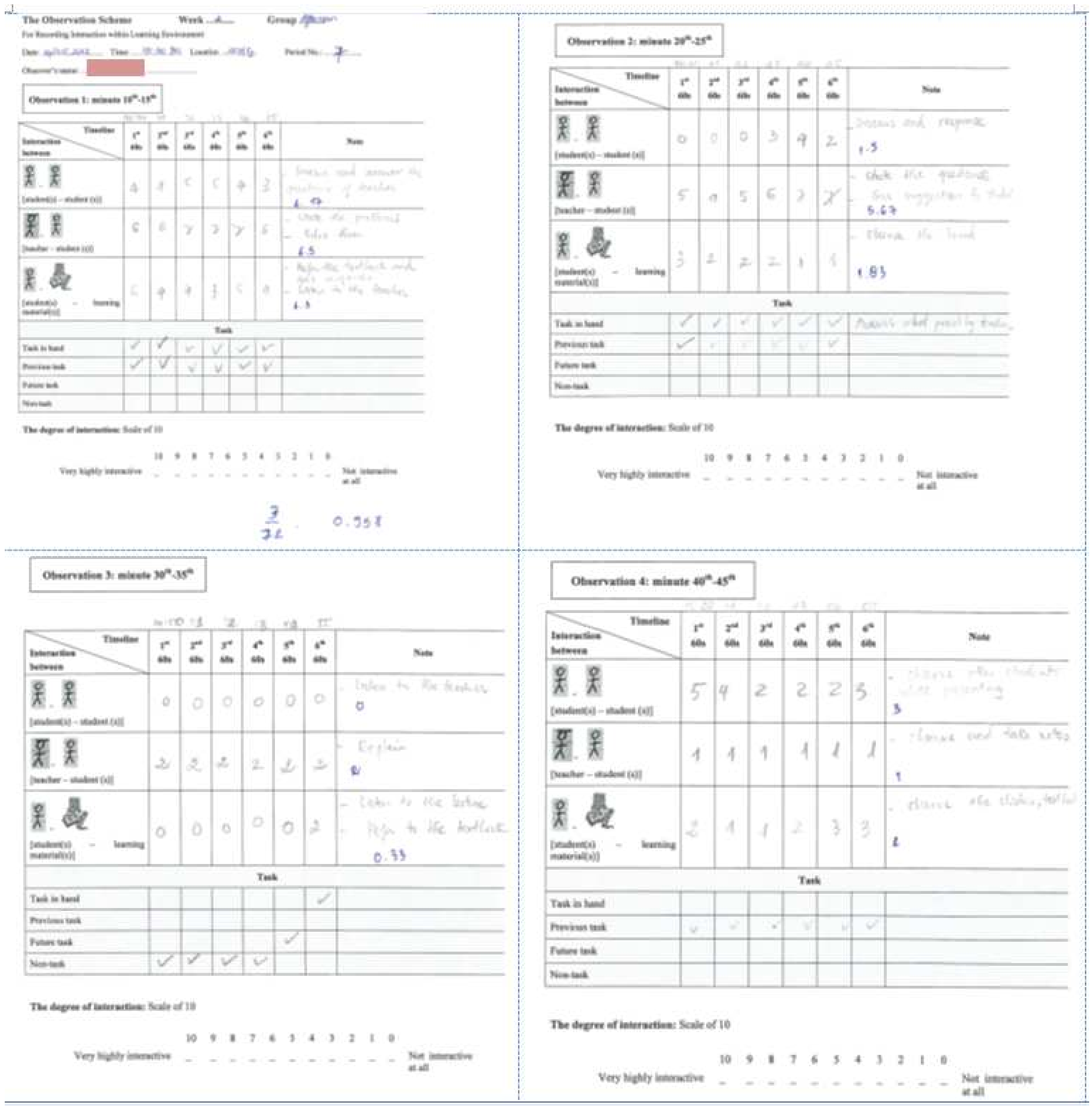


Figure 5.4 Seventy two cells (72 scores on interaction degrees of an observer) per period

During the first week of the semester, the optics lecturers introduced the course and did not teach. Lectures actually started from the second week. In week 2, two observers went to the classrooms and started to work together. The observations which occurred for two out of three morning hours had inter-rater reliability lower than 90%. The observations in week 2 did not meet the condition of inter-rater reliability. For this reason, observation data from week 3 and week 13 are used for comparison of the interaction degree of each group at the beginning and at the end of the semester.

Comparing the Interaction Degrees in the Class at the Beginning of the Semester to those at the End of the Semester

In the **Morning Group**, 216 average scores of interaction degrees in week 3 meet the condition of inter-rater reliability > 90%; in week 13, this number is 198. The average interaction degree (mean) of the Morning Group in week three is 3.36 (out of 10) (minimum score: 1, maximum score: 7) and 4.00 for week thirteen (minimum score: 0, maximum score: 7) (Table 5.2). The mean difference is 0.64 ($p = 0.000$) and Cohen's d 0.38 (modest). The interaction degree in the Morning Group increased slightly (0.64) but significantly.

In the **Afternoon Group**, the average interaction degree (mean) in week 3 is 2.9 (minimum score: 1, maximum score: 6.5); the interaction degree increased to 3.48 by week 13 (minimum score: 0, maximum score: 6) (Table 5.3). The effect size is modest (Cohen's d = 0.40) but the probability value is $p = 0.000$. The interaction degree of the Afternoon Group also increased slightly but statistically significantly. The difference in interaction degrees of the Morning Group (0.64) is larger than the difference of the Afternoon group (0.58); however the difference of these differences is not large (the difference of differences = 0.64 – 0.58 = 0.06).

Table 5.2 *Degree of Interaction – the Morning Group*

Week	N	Mean	SD	p (2-tailed) = 0.000 Mean Difference = 0.64 Cohen's d = 0.38
13	198	4.00	1.79	
3	216	3.36	1.56	

Table 5.3 *Degree of Interaction – the Afternoon Group*

Week	N	Mean	SD	p (2-tailed) = 0.000 Mean Difference = 0.58 Cohen's d = 0.40
13	180	3.48	1.48	
3	216	2.90	1.40	

Comparing the Interaction Degree between the Morning Group and the Afternoon Group

Table 5.4 shows that the interaction degrees of the Morning Group and the interaction degrees of the Afternoon Group are modestly different but statistically significant. The average interaction degree of the Morning Group in week three (3.36) is higher than those of the Afternoon Group (2.90) in the same week. Cohen's d of 0.31 indicates that this difference is modest while probability value of 0.001 indicates the difference is statistically significant.

Table 5.4 *Degree of Interaction – Week Three*

Group	N	Mean	SD	p (2-tailed) = 0.001 Mean Difference = 0.46 Cohen's d = 0.31
Morning	216	3.36	1.56	
Afternoon	216	2.90	1.40	

Table 5.5 presents the statistically significant difference in the interaction degree of the Morning Group and the Afternoon Group (p = 0.002). There are 198 average scores which satisfy the condition of inter-rater reliability in the Morning Group, and 180 average scores in the Afternoon Group. The average interaction degree of the Morning Group is 4.00; this number of the Afternoon Group is 3.48.

It means that the interaction degree of the Morning Group, on average, is higher than the interaction degree in the other group.

Table 5.5 *Degree of Interaction – Week Thirteen*

Group	N	Mean	SD	p (2-tailed) = 0.002 Mean Difference = 0.52 Cohen's d = 0.32
Morning	198	4.00	1.79	
Afternoon	180	3.48	1.48	

In general, the two groups are statistically significantly different from each other in terms of interaction degree. At week three, the average interaction degree of the Morning Group is 0.46 higher than the average interaction degree of the Afternoon Group; at week thirteen, this figure is 0.52. The difference between the two figures is 0.06 which confirmed the above calculation.

5.3.1.2 Questionnaire on Interaction

As mentioned on Chapter three, two questionnaires, which contained similar items inquiring information about interaction inside and outside the classroom, were administered to the students at the beginning and the end of the semester. The pre-questionnaire was delivered to the students at the beginning of the semester while the post questionnaire was received by the students at the end of the same semester. The twelve items in the pre-questionnaire aimed to investigate the interaction occurred in the courses of the previous semester (Semester I). The twelve items in the post-questionnaire had the similar content with the items in the pre-questionnaire; however, the items in the post-questionnaire inquired information about interaction performed in the Optics Course (Semester II).

This section will describe the findings from the data of the students' answers to these twelve questions. First, the interaction inside and outside the classroom of the Optics Course will be examined. Then, a comparison between this Optics Course and other courses in the previous semester in terms of interaction will be performed.

Students' Reflections on Interactions in this Optics Course

A questionnaire was administered at the end of the semester to 89 students who had attended the Optics Course. Twelve questions in the questionnaire focused on the interactions within the learning environment. The students were asked to assess how frequently they performed specific activities when they attended this Optics Course. These activities related to the interaction inside and outside the classroom.

Of the twelve questions, seven questions aimed at the interactions which occurred inside classrooms: (1) the lecturer asked questions; (2) the lecturer answered the questions; (3) the students asked questions, (4) the students contributed to the class discussion, (5) the students made class presentations, (6) the students worked with their classmates on tasks/assignments/projects and (7) the students came to class without completing readings or assignments. Answers to these questions were organised in five categories: *in every lecture*, *often*, *sometimes*, *rarely* and *not at all*.

The Cronbach's alpha of the first six items which relate directly to the interactions inside the classes is 0.671. In education research, alpha coefficient of 0.67 or above is considered acceptably reliable (Cohen et al., 2011). The seventh item '*students came to class without completing readings and assignment'* focuses on investigating to what extent the students had prepared the background knowledge for their discussion in the class. The item does not directly require information about the interactions inside the classes. Therefore, if the internal consistent reliability coefficient alpha of all seven items is calculated, the alpha is equal to 0.574.

The other five questions were also multiple choice questions. The answers comprised six categories: *once a week, once per two weeks, once a month, once per semester, not at all,* and *other*. These questions concentrated on the interactions happening outside the classroom: (1) the students worked on a paper or project that required integrating ideas or information from various sources; (2) the students worked with their classmates outside the class to prepare for class assignments/projects/tasks; (3) students used an electronic medium (Internet, forum, e-mail, instant messaging, chat group, etc.) to discuss academic issues with their classmates; (4) the students used electronic medium to communicate with an instructor; and (5) the students used an electronic medium to support doing groups assignments/projects/tasks. Cronbach's alpha coefficient of the five items measuring the interactions outside the classrooms is 0.726 which means it is reliable (Cohen et al., 2011).

After experiencing the implementation of the CSI Model into the Optics Course for a semester, at the end of this semester, the students were asked to evaluate how often the above twelve activities occurred in the course. Findings from the students' responses will be organised into two sections. The first section will present findings of interaction which occurred inside the classroom which disclosed from students' feedback on the first seven questions. The second section will then describe findings from interactions outside the classroom revealed from their responses to other five questions. The data for both groups was combined to generate the frequency graphs for the two sections. These findings will triangulate the findings from the student interviews, and the triangulation will be discussed in Section 5.4.

Interactions inside the Classroom

Findings from the students' responses showed that the lecturer usually asked questions during the lectures. Most of the students confirmed that the lecturer "often" asked questions in class or asked questions "in every lecture" (93%) (*Figure 5.5*). Only six (out of 89) students, 6.7%, said that the lecturer "rarely" or "sometimes" asked questions.

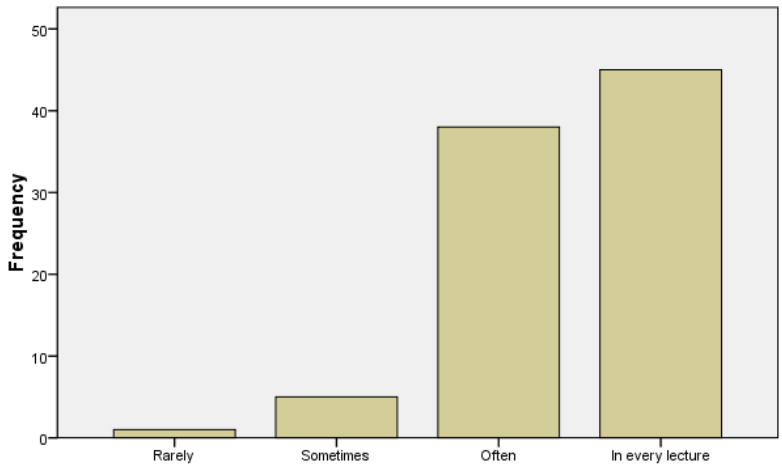


Figure 5.5 During the lectures, how often did the lecturer ask questions? – In class activities

Figure 5.6 presents students' opinions on how often the lecturer answered their questions during the lectures. Of 89 students, 45 students stated that the lecturers answered their questions *in every lecture*; 33 students confirmed he *often* answered their questions. This makes up to 88% of the students. It means that the students also usually raised questions during the lectures and these questions were answered by the lecturer.

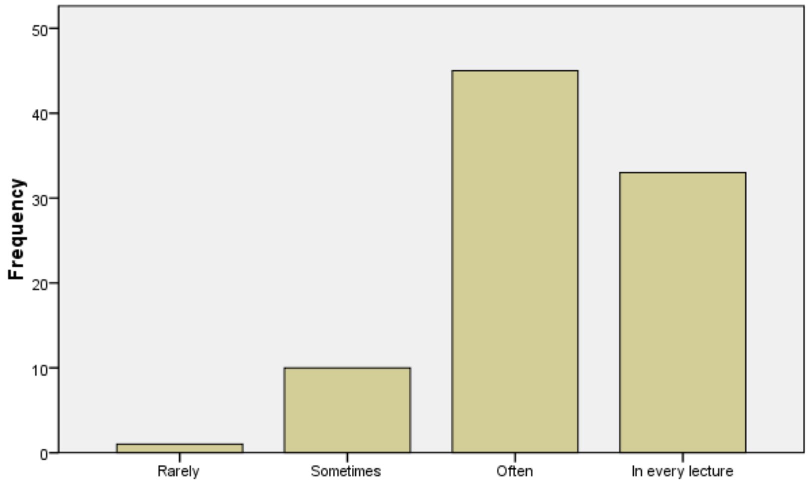


Figure 5.6 During the lectures, how often did the lecturer answer questions? - In class activities

In the questionnaire, the students were asked how often he/she asked questions in the class. The frequencies of the students' responses were distributed in an approximately bell-shape (*Figure 5.7*). The most popular answer was "*sometimes*" (53% of the students). Of the students, 17% replied "*often*" or "*in every class*", and 30% replied "*not at all*" or "*rarely*".

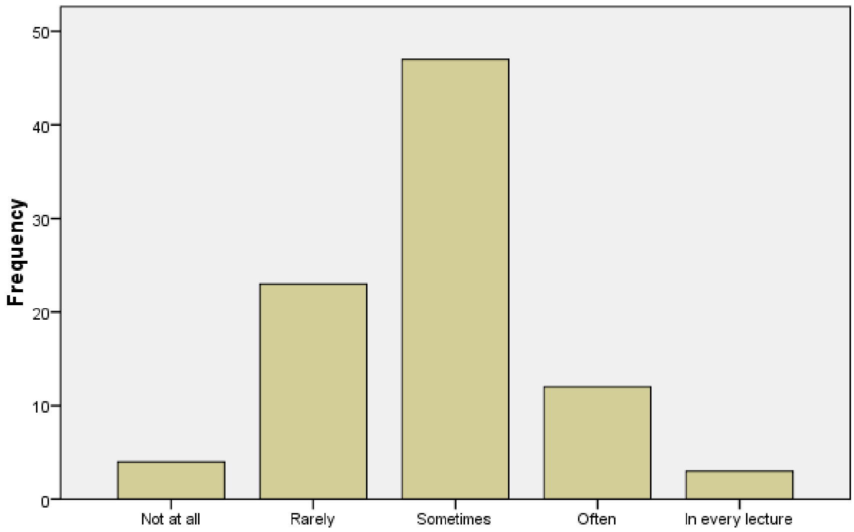


Figure 5.7 How often did you ask questions in class? - In class activities

The data, displayed in Figure 5.6 and Figure 5.7, indicate students sometimes asked questions in class. Each student contributed their questions to the whole class discussion. This made the total number of questions from 89 students quite substantial, and the frequency of the class asking questions or the lecturer answering the questions was high (*Figure 5.6*).

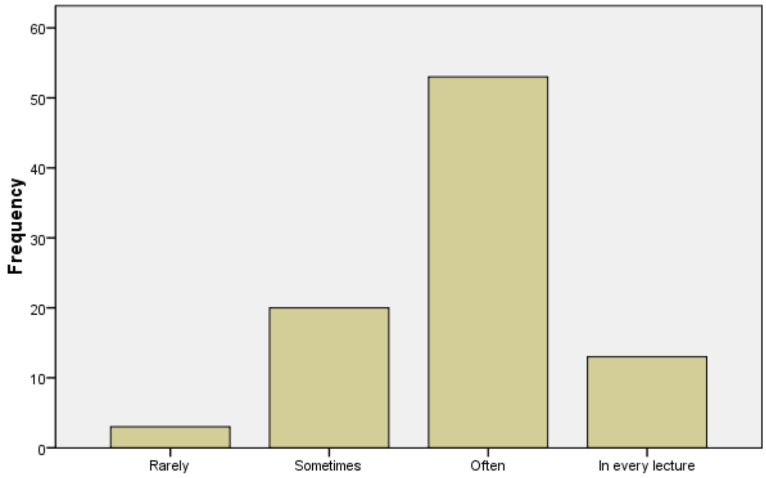


Figure 5.8 How often did you contribute to class discussions? - In class activities

For the question "*How often did you contribute to class discussions?*", a majority of the students stated that they contributed to the class discussion quite regularly. Sixty six students (74%) answered "*often*" or "*in every class*" while 20 students answered "*sometimes*". Only three answered "*rarely*" (*Figure 5.8*).

Figure 5.9 shows the frequencies of students' answers on how often they made a class presentation. The students' responses are in an approximately normal distribution. The most popular answer - *sometime* - were replied by 55 (out of 89) students (62%). The second popular answer was "*often*", responded by 15 students (17 %); and the least popular answer was "*in every class*", replied by only two students.

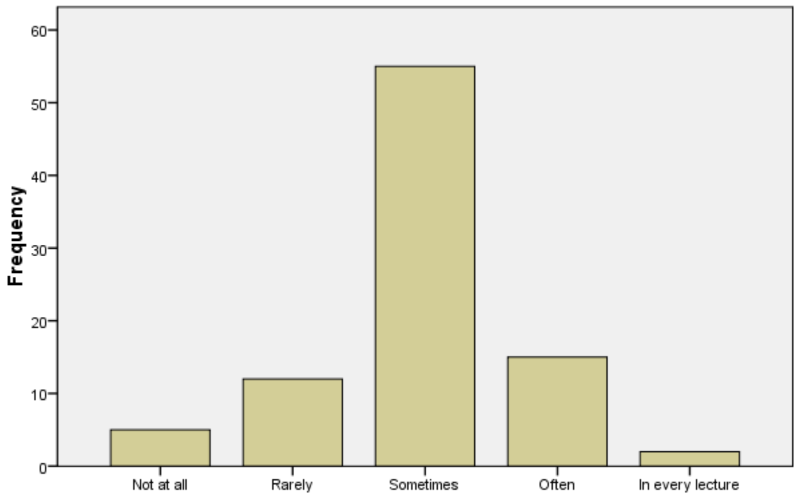


Figure 5.9 How often did you make a class presentation? - In class activities

The distribution of the students' responses on how often they worked with their classmates on tasks/assignments/projects presented inside the class is presented in *Figure 5.10*. Of 89 students who completed this item, 59 students (66.3%) self-evaluated that they *often* worked with their classmates on a learning task in class, while a relative small number (3 students) thought they *rarely* did.

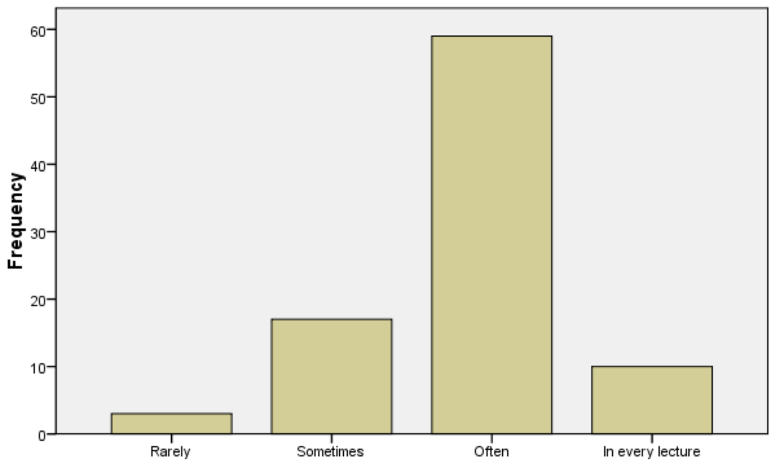


Figure 5.10 How often did you work with classmates on tasks/assignments/projects - In class activities

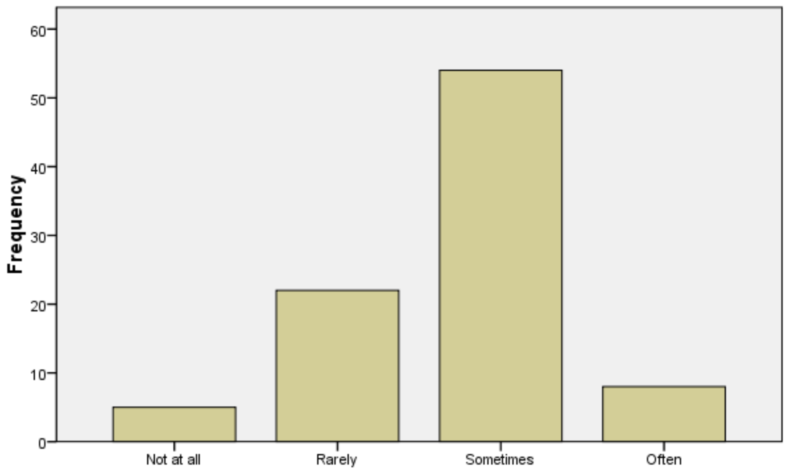


Figure 5.11 How often did you come to class without completing readings or assignments?

Figure 5.11 describes the frequencies of students going to classes without completing readings or assignments. Most of the respondents disclosed that they *sometimes* or *rarely* went to classes without completing readings or homework (85%). A small number of students responded the question as *often* (8 students - 9%).

Interactions outside the Classroom

Students' self-evaluation of how often they had worked on a paper or project that required integrating ideas or information from various sources is displayed in *Figure 5.12*. Forty-three out of eighty-eight students stated that the frequencies of their work mentioned in this question were *every week/ once per two weeks/ once a month* (49%). Twenty-nine students responded *once per semester* (33%), and 16 students for *not at all* (18%).

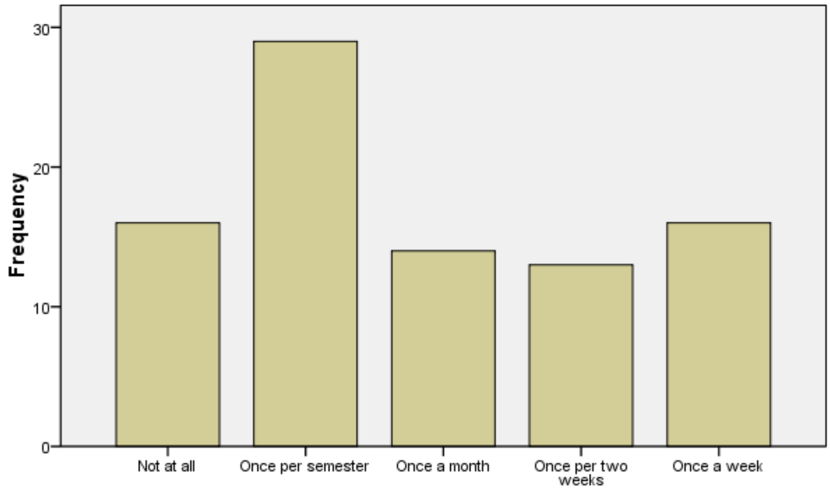


Figure 5.12 Working on a paper or project that required integrating ideas or information from various sources - Out of classroom

The result of students' responses in *Figure 5.13* to the question how often they worked with their classmates outside of the class to prepare for class assignments/projects/tasks were skewed, with only 10 responses (11%) being in the first three categories: *other*, *not at all* and *once per semester*. Most of students (78 students - 89%) claimed that they worked with their classmates outside the class *once a week/once per two weeks/ once a month* to prepare for learning tasks.

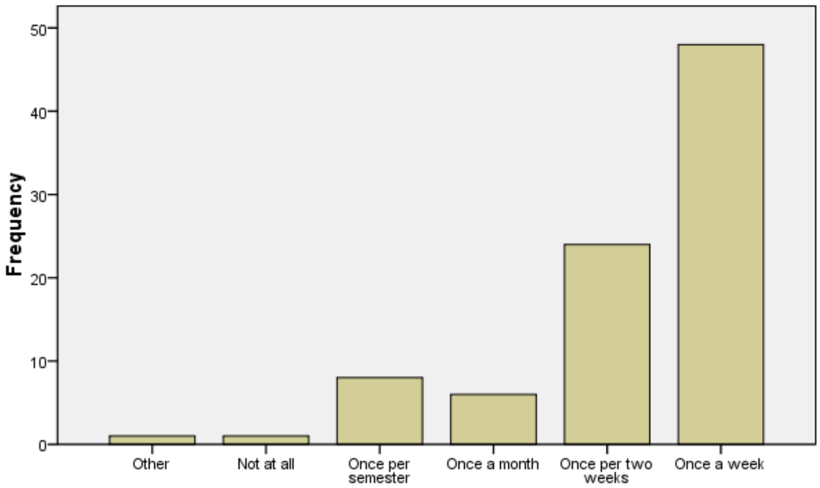


Figure 5.13 Working with classmates outside the class to prepare for class assignments/projects/tasks

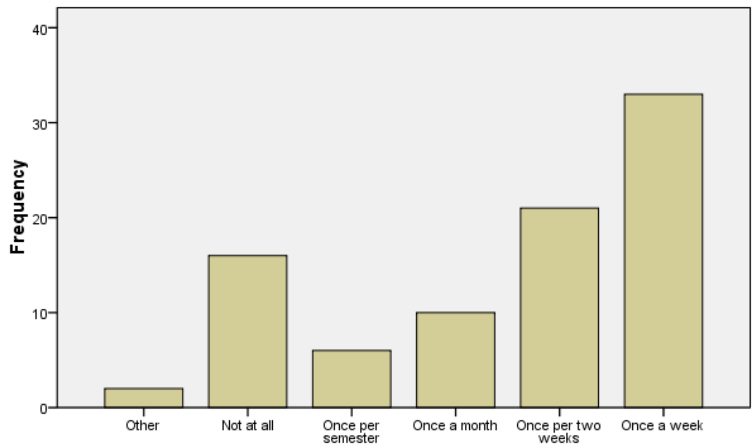


Figure 5.14 Using an electronic medium to discuss with classmates about academic issues - Out of classroom

Figure 5.14 illustrates the frequencies of the students' uses of electronic media to discuss academic issues with their classmates. The trend of the students' responses in this graph is rather similar to those in *Figure 5.13*. A majority of the students (54 students – 61%) said that they used electronic media *once a week* or *once per two weeks* for this purpose. Ten students (11%) stated they used the media to discuss academic issues with their peers *once a month*. This number for "*not at all"* and *"once per semester*" is eighteen students (21%).

Students' questionnaire data indicated that the students' use of electronic media to communicate with the lecturer were not as regular as to communicate with their classmates. Of the respondents, 32% (28 out of 87) answered that they used the media to communicate with the lecturer *once a week* or *once per two weeks*, this number for "*once a month"* were 11 respondents (*Figure 5.15*). Forty-seven respondents (55%) said that they used electronic media for this purpose *"once per semester"*.

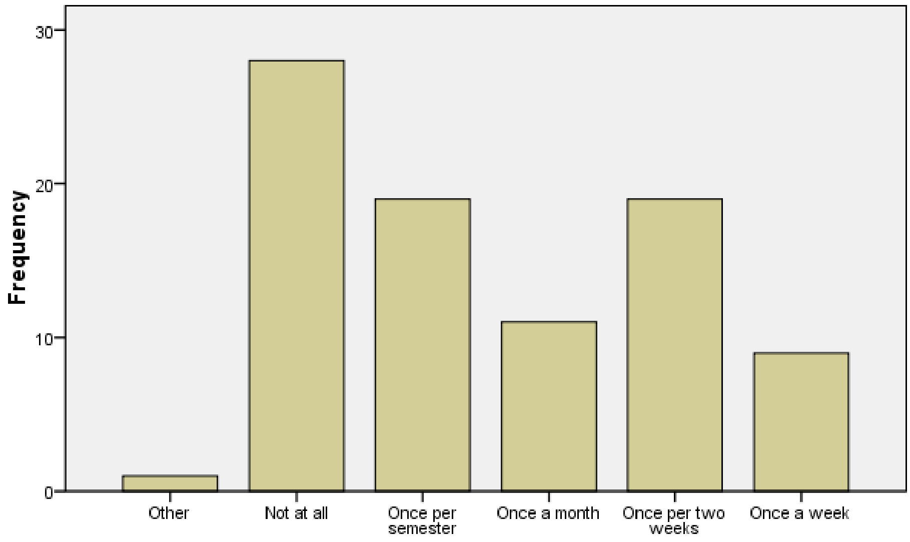


Figure 5.15 Using an electronic medium to communicate with the lecturer - Out of classroom

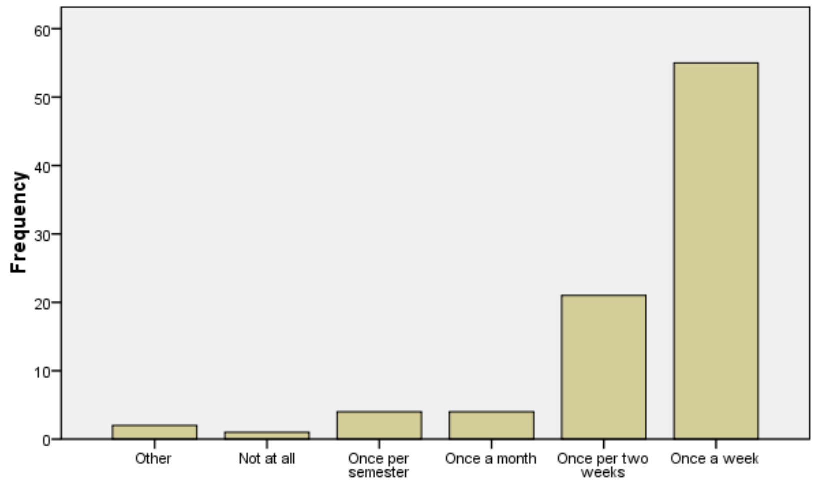


Figure 5.16 Using an electronic medium to support doing group assignments/projects/tasks - Out of classroom

In contrast to the use of electronic media to communicate with the lecturer, the students regularly used electronic media to support doing group assignments/projects/tasks. Most of students (76 out of 87 students - 87%) confirmed that they used the media *once a week* or *once per two weeks* to support doing group work (*Figure 5.16*). Eight students (9%) said that they used this media *once a month* or *once per semester*.

In summary, the data from the students' questionnaire revealed that there was a reasonable interaction frequency inside and outside the class. According to most of the students, *inside the class*, the lecturer often asked questions and the students also asked questions regularly. A majority of the students noted that they contributed to the class discussion and worked with their classmates on an in-class-learning task frequently. Individual students generally said that they sometimes presented an optics topic in class; they also sometimes went to class without completing homework.

Outside the class, the students reported that they often worked with their classmates to conduct learning tasks. More than two thirds of the students (67%) believed that they did not work on a paper or a project that required integrating ideas or information from various sources. In the students' opinion, their use of electronic media to support group work and discussion with their classmates about academic issues was rather frequent. The students in general did not use electronic media to communicate with the lecturer as regularly as to discuss with their peers.

Comparing Interactions in this Optics Course and Other Courses

As discussed above, the pre-questionnaire and post-questionnaire were administered to the students in order to acquire information about interactions which occurred in the Optics Course and the courses that had been provided in the previous semester. There were seven questions focussing on interactions occurred inside the classroom, and the answers of five Likert's scale were coded as: 5 - *in every lecture*, 4 - *often*, 3 - *sometimes*, 2 - *rarely* and 1 - *not at all*. The answers to the five questions seeking interactions happening outside the classroom were also coded: 5 - *once a week*, 4 - *once per two weeks*, 3 - *once a month*, 2 - *once per semester*, 1 - *not at all*, and 0 - *other*.

To examine whether interactions in the Optics Courses were higher than interactions in other courses, a t-test was performed. Comparisons between means of the twelve items in the pre-questionnaire and those in the post-questionnaire were made. Differences between the means are considered statistically significant if the probability values in those cases are larger than 0.05.

Table 5.6 displays t-test results of frequencies of activities reflecting interactions inside the class. For the item *'B1 During the lectures, how often did the instructor ask questions?'*, the mean for the Optics Course (mean = 4.43) is significantly higher than the mean for other courses (mean = 4.04); probability value is 0.000. As mentioned in Chapter three, effect size strength suggested by Cohen et al. (2007) is : 0.00 – 0.20 as weak effect size, 0.21 – 0.50 as modest effect size, 0.51 – 1.00 as moderate effect size and larger than 1.00 as strong effect size. Cohen's d = 0.54 of this item reflects the moderate effect size.

Table 5.6 *Activities Occurred Inside the Classroom – Comparing Between This Optics Course and Other Courses*

Items	Optics/ others	N	Mean	SD	Mean difference & p (1-tailed)
B1. During lectures, how often did the instructor ask questions? - In class activities	Optics	89	4.43	.655	Mean difference = .394 p (1-tailed) = .000* Cohen's d = .54
	Others	90	4.03	.814	
B2. During lectures, how often did the instructor answer the questions? - In class activities	Optics	89	4.24	.691	Mean difference = .336 p (1-tailed) = .001 Cohen's d = 0.49
	Others	90	3.90	.671	
B3. How often did you ask questions in class? - In class activities	Optics	89	2.85	.833	Mean difference = .154 p (1-tailed) = .086
	Others	90	2.70	.661	
B4. How often did you contribute to class discussions? - In class activities	Optics	89	3.85	.700	Mean difference = .087 p (1-tailed) = .201
	Others	90	3.77	.688	
B5. How often did you make a class presentation? - In class activities	Optics	89	2.97	.790	Mean difference = .311 p (1-tailed) = .004 Cohen's d = .40
	Others	90	2.66	.767	
B6. How often did you worked with classmates on tasks/assignments/projects - Inside class activities	Optics	89	3.85	.649	Mean difference =.176 p (1-tailed) = .038 Cohen's d = 0.27
	Others	90	3.68	.668	
B7. How often did you come to class without completing readings or assignments? - In class activities	Optics	89	2.73	.703	Mean difference = .045 p (1-tailed) = .346
	Others	89	2.69	.806	

**Shaded areas indicate significance*

For the three items '*B2 During the lectures, how often did the instructor answer the questions?*', '*B5 How often did you make a class presentation?*', and '*B6 How* *often did you work with classmates on tasks/assignments/projects*', the means for Optics Course are also significantly higher than the means for other courses with probability values smaller than 0.05. Cohen's d of the items are in the range of 0.27 – 0.49 which indicates modest effect size. In other words, the activities indicating interactions inside the class (e.g. lecturer asking and answering questions, students presenting and working with classmates) occurred in the Optics Course more frequently than in the other courses.

For the other three items (B3, B4 and B7) in Table 5.6, there is a trend that the means for the Optics Course are higher than the other courses. However, the probability values are larger than 0.05. It indicates that the differences in the means are not statistically significant.

Table 5.7 shows t-test results of frequencies of activities reflecting interactions outside the class. The means and mean differences in item B8 to B11 suggest that there is a tendency that the activities indicating interactions outside the class occurred more frequently in the Optics Course than in the other courses. However, the probability values of these items are larger than 0.05; this shows that the differences are not statistically significant. For item *B12*, The students used an electronic medium to support doing groups assignments/projects/tasks outside the class in the Optics Course more regularly than in other courses. This result is statistically significant (mean difference = 0.761, p = 0.000).

Table 5.7 *Activities Occurred Outside the Classroom – Comparing Between This Optics Course and Other Courses*

	Optics/ others	N	Mean	SD	Mean difference & p (1-tailed)
B8. Worked on a paper or project that required integrating ideas or information from various sources - Out of classroom	Optics	88	2.82	1.386	Mean difference = .232 p (1-tailed) = .135
	Others	87	2.59	1.394	
B9. Worked with classmates outside of class to prepare class assignments/projects/tasks - Out of classroom	Optics	88	4.22	1.108	Mean difference = .194 p (1-tailed) = .146
	Others	90	4.02	1.324	
B10. Used an electronic medium to discuss with classmates about academic issues - Out of classroom	Optics	88	3.49	1.590	Mean difference = .100 p (1-tailed) = .344
	Others	90	3.39	1.714	
B11. Used electronic medium to communicate with an instructor - Out of classroom	Optics	87	2.53	1.429	Mean difference = .276 p (1-tailed) = .104
	Others	87	2.25	1.440	
B12. Used an electronic medium to support doing groups assignments/projects/tasks - Out of classroom	Optics	87	4.37	1.101	Mean difference = .761 p (1-tailed) = .000*
	Others	89	3.61	1.482	

**Shaded area indicate significant*

Comparing Morning Group and Afternoon Group

Since there were two groups of students who participated in the research and the Morning Group used the LMS while the Afternoon Group did not, comparisons of students' reflection upon the interactions in the Optics Course between the two were also conducted. Responses to the post-questionnaire of the Morning-Group students were compared with those of the Afternoon-Group students. Differences were considered statistically significant if the probability values in those cases were larger than 0.05.

Table 5.8 *Activities Occurred Inside the Classroom – Comparing Between the Morning Group and the Afternoon Group*

Items	Group	N	Mean	SD	Mean difference & p (2-tailed)
B1. During lectures, how often did the instructor ask questions? - In class activities	Morning	54	4.46	.636	Mean difference = .092 p (2-tailed) = .523
	Afternoon	35	4.37	.690	
B2. During lectures, how often did the instructor answer the questions? - In class activities	Morning	54	4.33	.644	Mean difference = .248 p (2-tailed) = .099
	Afternoon	35	4.09	.742	
B3. How often did you ask questions in class? - In class activities	Morning	54	2.96	.910	Mean difference = .277 p (2-tailed) = .126
	Afternoon	35	2.69	.676	
B4. How often did you contribute to class discussions? - In class activities	Morning	54	3.96	.699	Mean difference = .277 p (2-tailed) = .068
	Afternoon	35	3.69	.676	
B5. How often did you make a class presentation? - In class activities	Morning	54	3.00	.801	Mean difference = .086 p (2-tailed) = .620
	Afternoon	35	2.91	.781	
B6. How often did you work with classmates on tasks/assignments/project s - Inside class activities	Morning	54	4.00	.583	Mean difference = .371 p (2-tailed) = .011
	Afternoon	35	3.63	.690	
B7. How often did you come to class without completing readings or assignments? - In class activities	Morning	54	2.70	.690	Mean difference = -.068 p (2-tailed) = .660
	Afternoon	35	2.77	.731	

Table 5.9 *Activities Occurred Outside the Classroom – Comparing Between the Morning Group and the Afternoon Group*

Items	Group	N	Mean	SD	Mean difference & p (2-tailed)
B8. Worked on a paper or project that required integrating ideas or information from various sources - Out of classroom	Morning	54	2.83	1.450	Mean difference = .039 p (2-tailed) = .898
	Afternoon	34	2.79	1.298	
B9. Worked with classmates outside of class to prepare class assignments/projects/tasks - Out of classroom	Morning	54	4.39	.940	Mean difference = .448 p (2-tailed) = .065
	Afternoon	34	3.94	1.301	
B10. Used an electronic medium to discuss with classmates about academic issues - Out of classroom	Morning	54	3.50	1.575	Mean difference = .029 p (2-tailed) = .933
	Afternoon	34	3.47	1.637	
B11. Used electronic medium to communicate with an instructor - Out of classroom	Morning	53	2.70	1.488	Mean difference = .433 p (2-tailed) = .169
	Afternoon	34	2.26	1.310	
B12. Used an electronic medium to support doing groups assignments/projects/tasks - Out of classroom	Morning	54	4.48	1.023	Mean difference = .300 p (2-tailed) = .220
	Afternoon	33	4.18	1.211	

Table 5.8 and Table 5.9 display the t-test results from the frequencies of the activities indicating interactions inside and outside the classroom. The t-test result of item *B6* shows that the Morning-Group students worked with their classmates on tasks/assignments/projects inside the class more often than the Afternoon-

Group students, and this result is statistically significant (mean difference = 0.371, p = 0.011). The two tables indicates that the activities indicating interactions occurred more often in the Morning Group than in the Afternoon Group; yet these differences are not statistically significant (probability values > 0.05).

5.3.2 *Optics Tests*

The optics test was an exam paper which has been used since 2009. The test included 40 items and was designed by the lecturer, and the same test was used for pre- and post-tests. The optics content related to the tests is shown in Table 5.10 To examine if the students' optics performance had improved after the implementation of the CSI Model, the students' scores between pre-test and post-test was compared. In this research, the assumption of normality was made. In order to test the assumption, the tests of normality (Shapiro-Wilk Test) were conducted on the data of the Morning-Group optics pretest and postest. Test results showed that p-value of the pre-test was 0.38, and p-value of the post-test was 0.28. Based on this, it was concluded that the data conformed to a normal distributions.

As mentioned in Chapter three, the implementation of the CSI Model into the Morning Group and the Afternoon Group was slightly different: The Morning Group used LMS while the Afternoon Group did not. Therefore, a comparison of students' scores between the Morning Group and the Afternoon Group will be conducted in order to investigate whether the use of LMS could make a difference.

Comparing the Students' Scores between Pre- and Post-Tests

In the Morning Group, the number of students who attended the pre-test was 46, and this rose to 53 for the post-test. So there were 46 students in the Morning

Group who attended both pre- and post-tests. These students were the ones whose data was analysed.

In the Afternoon Group, the number of students who attended the pre-test was 46; and this number reduced to 35 by the time of the post-test. So in the Afternoon Group, 32 students sat both tests, and these are the ones whose data was analysed.

The paired-samples t-tests were used to examine the impact of the model implementation. The use of paired-samples t-tests meant that only test scores of students who attended both pre-test and post-test were used for the comparison in the t-test. In the Morning Group, the test scores of 46 students who sat both tests were used to conduct the t-test, while in the Afternoon Group, the test scores of 32 students were used.

By using the paired-samples t-tests in this case where there were noticeable differences in the numbers of students of each group between the pre- and post-tests, the t-test results reflected accurate changes in students' test scores. There might be an assumption that some students in the Afternoon Group who scored very low in the pre-test might drop out of the course and the post-test results would not include the scores of these students. As a result, the mean of the post-test scores might be higher than the mean of the pre-test scores. By only using paired-samples, the risk that the increase in the scores in the Afternoon Group was caused by student drop out was eliminated.

The results of the students' optics tests show that there are statistical significant differences between pre-test and post-test results of the students in both groups. In general, the test scores in the post-test are higher than the scores in the pre-test. The following statistics will explain in detail the differences in the test scores.

Table 5.10 *Optics Test*

Test Item No.	Optics Content
1.	Telescope
2.	Prism
3.	Diffraction
4.	Optical interference – Young's experiment (interference given by double slits)
5.	Optical interference – Newton's rings (interference created by reflection of light from spherical surface and flat surface)
6.	Black body
7.	Nature of electromagnetic waves
8.	Continuous spectrum
9.	Optical interference – Young's experiment (interference given by double slits)
10.	Convex lens
11.	Reflection and refraction
12.	Convex lens
13.	Optical interference – Newton's rings (interference created by reflection of light from spherical surface and flat surface)
14.	Hydrogen emission spectrum lines
15.	Convex lens
16.	Microscope
17.	Hand lens (magnifying glass)
18.	Photoelectron effect
19.	Interference
20.	Optical interference – Young's experiment
21.	Photoelectron effect
22.	Fresnel diffraction
23.	Polariser
24.	Black body
25.	Diffraction
26.	Photoelectron effect
27.	Concave mirror
28.	Prism
29.	Polarised light
30.	Quantum optical formulas
31.	Wave length of light and temperature of objects
32.	Hand lens (magnifying glass)
33.	Polariser
34.	Diffraction - Fresnel zone plates
35.	Polarisation: polarising light by scattering
36.	Unit if illuminance (Lux)
37.	Methods of measuring the speed of light
38.	Diffraction - Fresnel zone plates
39.	Unit of luminous intensity (Cd – Candela)
40.	Telescope Celestron of the Physics Department (CTU)

Table 5.11 presents the paired-samples test results of the Morning Group. The mean of pre-test is 13.37 (out of 40) and post-test 28.76. Mean difference is 15.39 (p = 0.000) and effect size - Cohen's d[1] = 3.80 (strong). The Cohen's d is computed as:

$$Cohen's\ d = \frac{Mean\ difference}{Pooled\ standard\ deviation}$$

While:

$$Pooledstandarddeviation = \frac{(SDgroup\ 1 + SDgroup\ 2)}{2}$$

$$= \frac{(4.26 + 3.84)}{2}$$

$$Pooled\ standard\ deviation = \ 4.05$$

Therefore: $Cohen'sd = \frac{Meandifference}{Pooledstandarddeviation} = \frac{15.39}{4.05} = 3.80$

The Cohen's d above 1.0 indicates the effect size strong; the Cohen's d '3.80' can be considered as a very strong effect. The statistic (p = 0.000 and Cohen's d = 3.80) proves that there was a large effect with a substantial difference in the test scores achieved by the students at the beginning and at the end of the semester. The mean difference = 15.39 (p = 0.000, Cohen's d = 3.80) suggests that in the

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[1] Effect size Cohen's d strength :

0.00 – 0.20: small effect

0.21 – 0.50: modest effect

0.51 – 1.00: moderate effect

>1.00: strong effect

Morning Group, the students' optics test scores improve considerably and significantly.

Table 5.11 *Optics Test Results of the Morning Group*

	N	Mean	SD	p (2-tailed) = 0.000 Mean Difference = 15.39 Cohen's d = 3.80
Post-test	46	28.76	4.26	
Pre-test	46	13.37	3.84	

The above table and numbers can be explained in a simple way as the average number of correct answers which a student in the Morning Group performed in the optics pre-test is 13.37 out of 40 answers; this number for the optics post-test is 28.76. It means that Morning-Group students' post-test scores were higher than their pre-test scores, and a student generally in the post-test performed 15.39 correct answers more than himself/herself in the pre-test. In statistical terms, if the probability value (p) is equal or less than 0.05, the result will be considered as statically significant. The probability value '0.000' in Table 5.11 is substantially smaller than the specified probability value of 0.05. Therefore, it is concluded that there was a significant increase of 15.39 (out of 40) in the optics test scores from the pre-test (prior to the model implementation) to post-test (after the model implementation).

Table 5.12 *Optics Test Results of the Afternoon Group*

	N	Mean	SD	p (2-tailed) = 0.004 Mean Difference = 3.80 Cohen's d = 0.85
Post-test	32	16.77	6.45	
Pre-test	32	12.97	2.44	

Table 5.12 presents a comparison between students' result on optics pre-test and post-test (paired-sample t-test). There was a statistical significant difference between pre-test and post-test of the students in the Afternoon Group. Mean of pre-test is 12.97, and mean of post-test is 16.77. Mean difference is 3.80 (p = 0.004) and effect size - Cohen's d = 0.85 (moderate).

The average number of correct answers that students in the Afternoon Group scored in the optics pre-test is 12.97 (per 40 answers totally), for the post-test – 16.77. Mean difference 3.80 refers that on average, each student gains 3.80 correct answers more in the post-test, in comparison with the pre-test. Probability value 0.004 and Cohen's d = 0.85 reveal that the optics test scores of the Afternoon Group increase moderately and significantly.

Comparing the Morning Group and the Afternoon Group

An independent sample t-test was conducted to evaluate the difference between the two groups. The students' pre-test results show that there is no statistical significant difference between the Morning Group and the Afternoon Group (mean difference = 0.445, p = 0.515) (Table 5.13). In simple words, the Morning Group and the Afternoon Group is considered to be similar to each other in the optics test scores at the beginning of the semester.

Table 5.13 *Optics Pre-test Results of the Morning and Afternoon Group*

Group	N	Mean	SD	p (2-tailed) = 0.515 Mean Difference = 0.45
Morning	46	13.37	3.84	
Afternoon	40	12.93	2.39	

Table 5.14 describes a comparison of optics post-test results between the Morning Group and the Afternoon Group. The mean of the Morning Group post-test is 28.74, and 16.77 for the Afternoon Group. Mean difference is 11.96 (sig. 0.000) and effect size – Cohen's d = 2.23 (strong effect). At the end of the semester, the students in the Morning Group performed about 12 correct answers (out of totally 40 answers) more than the students in the Afternoon Group. The post-test results of the students in the Morning Group are significantly higher than the results of the Afternoon Group.

Table 5.14 *Optics Post-Test results of the Morning and Afternoon Group*

<table>
<tr><td>Group</td><td>N</td><td>Mean</td><td>SD</td><td rowspan="3">p (2-tailed) = 0.000
Mean Difference = 11.96
Cohen's d = 2.23</td></tr>
<tr><td>Morning</td><td>53</td><td>28.74</td><td>4.28</td></tr>
<tr><td>Afternoon</td><td>35</td><td>16.77</td><td>6.45</td></tr>
</table>

Comparing the Current Semester and the Previous Semester

To investigate the influence of the CSI Model on the students' optics performance, a comparison of test scores of two groups of students were conducted. One group of students, Semester I Group, studied with the same lecturer, but did not experience the intervention of the CSI Model implementation. This group studied the optics course in Semester I of school year 2011-2012. The other groups, the Morning Group and the Afternoon Group, who attended the course in Semester II of the same school year, experienced the implementation of the model.

At the end of Semester I, the Semester I Group took a similar optics test as the test that the Morning Group and the Afternoon Group did. These two tests aimed at measuring the students' understanding of optics knowledge at the end of the semesters. Both of them included 40 items and were designed by the lecturer.

Table 5.15 describes the test results of the Semester I Group students and the Morning Group students. There were 58 students in the first group who took the optics test. The minimum score is 5 (out of 40), maximum score 17. The average score is 11.02 (Standard Deviation (SD) = 2.626).

The t-test result indicates that the mean of the Morning Group (the experimental group) – 28.74 is significantly higher than the mean of the Semester I Group – 11.02 (mean difference = 17.72, p = 0.000). According to Cohen et al. (2011), Cohen's d > 1.0 is considered strong effect size. In this case, Cohen's d = 5.13 shows very strong effect.

Table 5.15 *Optics Test Results of Semester I Group and Morning Group*

Group	N	Mean	SD	Mean difference = 17.72 p (2-tailed) = 0.000 Cohen's d = 5.13
Semester I Group	58	11.02	2.626	
Morning Group *	53	28.74	4.284	

** This group experienced the CSI Model implementation*

The t-test result which compares optics test results of the Semester I Group and the Afternoon Group is displayed in Table 5.16. The test scores of the Afternoon Group is significantly higher than those of the Semester I Group (mean difference = 5.75, p = 0.000). The effect size, Cohen's d = 1.27, is strong.

Table 5.16 *Optics Test Results of Semester I Group and Afternoon Group*

Group	N	Mean	SD	Mean difference = 5.75
Semester I Group	58	11.02	2.626	p (2-tailed) = 0.000 Cohen’s d = 1.27
Afternoon Group *	35	16.77	6.445	

** This group experienced the CSI Model implementation*

The results presented in Table 5.15 and Table 5.16 indicate that the two groups experiencing with implementation of the CSI Model (The Morning and Afternoon Groups) scored higher than the group who did not experience this implementation (the Semester I Group). This result is statistically significant with the probability value of p (2-tailed) = 0.000.

5.3.3 The Students’ Critical Thinking Skills

5.3.3.1 Critical Thinking Skills Tests

Comparing the Students’ Scores between Pre- and Post-Tests

California Critical Thinking Skills Test was employed in the research. The test was purchased from Insight Assessment. The same test is used for pre- and post-test. The test results show that there are statistically significant differences in total score and five individual scale scores of students’ pre-test and post-test.

Table 5.17 *Optics Test Results of the Combined Group (Including Morning and Afternoon Group)*

Critical thinking skills	Pre/Post	N	Mean	SD	Mean difference p (2-tailed)
Total	Post	89	13.72	3.50	Mean difference = 1.80 p (2-tailed) = 0.001 Cohen's d = 0.53 (moderate)
	Pre	90	11.92	3.31	
Analysis & Interpretation	Post	89	4.09	1.28	Mean difference = 0.41 p (2-tailed) = 0.037 Cohen's d = 0.31 (modest)
	Pre	90	3.68	1.34	
Inference	Post	89	6.19	2.15	Mean difference = 0.85 p (2-tailed) = 0.009 Cohen's d =0.39 (modest)
	Pre	90	5.34	2.16	
Evaluation & Explanation	Post	89	3.44	1.48	Mean difference = 0.54 p (2-tailed) = 0.017 Cohen's d = 0.36 (modest)
	Pre	90	2.90	1.50	
Induction	Post	89	6.98	2.39	Mean difference = 0.89 p (2-tailed) = 0.009 Cohen's d = 0.40 (modest)
	Pre	90	6.09	2.09	
Deduction	Post	89	6.74	2.38	Mean difference = 0.91 p (2-tailed) = 0.009 Cohen's d = 0.39 (modest)
	Pre	90	5.83	2.26	

The CCTST results of the students (in both groups) shows that critical thinking skills scores of the students in the post-test is significantly higher than in the pre-test (Table 5.17). The mean of the total score in the post-test increases 1.8 (out of 34) ($p = 0.001$) compared with the pre-test. The five critical thinking sub-scores:

analysis & interpretation, inference, evaluation & explanation, induction and deduction also improved statistically significantly by the end of the semester ($p \leq 0.037$). The figures in this table show that the means of the thinking skills *inference*, *induction* and *deduction* increase more than the means of *analysis & interpretation* skills and *evaluation & expl*anation skills. The mean differences of *inference*, *induction* and *deduction* skills are 0.85, 0.89 and 0.91 respectively, while the mean difference of *analysis & interpretation* is 0.41 and *evaluation & explanation* 0.54.

Comparing the Morning Group and the Afternoon Group

Table 5.18 shows the t-test results which compare pre-test scores on critical thinking skills of the students' in the Morning-Group to those in the Afternoon Group. The probability values of all scores (e.g. total, analysis & interpretation, inference, evaluation & explanation, induction and deduction) are larger than 0.05 (not significant). Similarly, Table 5.19 presents the t-test result comparing these scores of the students in the two groups in the post-test. The probability values of the scores are also larger than 0.05.

In general, there are no statistical significant differences between the test scores of the Morning Group and the Afternoon Group in both pre-tests and post-test (probability levels of the scores are all above 0.05). It means that in terms of the critical thinking skills of the students, the Morning Group was nearly identical to the Afternoon Group at the points of time when the pre-test and the post-test occurred (i.e. the beginning and the end of the semester).

In Table 5.17, the students' critical thinking scores in pre-test and post-test are compared. In the comparison, the Morning Group and Afternoon Group have been combined into a big group of about ninety students. It is meaningless to compare the pre-test and post-test results of the two groups separately when they are not statistically significantly different in terms of thinking skills. Thus, the insignificant differences between the Morning Group and the Afternoon Group in the students' scores are the main reason for this combination.

Table 5.18 *CCTST Pre-test Result - the Morning Group and the Afternoon Group*

Critical thinking skills	**Group**	**N**	**Mean**	**SD**	**Mean difference p (2-tailed)**
Total	Morning	51	12.10	3.401	Mean difference = 0.41 p (2-tailed) = 0.567
	Afternoon	39	11.69	3.205	
Analysis & Interpretation	Morning	51	3.84	1.377	Mean difference = 0.38 p (2-tailed) = 0.182
	Afternoon	39	3.46	1.274	
Inference	Morning	51	5.47	2.082	Mean difference = 0.29 p (2-tailed) = 0.530
	Afternoon	39	5.18	2.281	
Evaluation & Explanation	Morning	51	2.78	1.604	Mean difference = -0.267 p (2-tailed) = 0.41
	Afternoon	39	3.05	1.356	
Induction	Morning	51	6.00	2.191	Mean difference = -0.21 p (2-tailed) = 0.65
	Afternoon	39	6.21	1.976	
Deduction	Morning	51	6.10	1.952	Mean difference = 0.61 p (2-tailed) = 0.2196
	Afternoon	39	5.49	2.501	

Table 5.19 *CCTST Post-test Result - the Morning Group and the Afternoon Group*

Critical thinking skills	Group	N	Mean	SD	Mean difference p (2-tailed)
Total	Morning	53	14.21	3.629	Mean difference = 1.21 p (2-tailed) = 0.110
	Afternoon	36	13.00	3.207	
Analysis & Interpretation	Morning	53	4.28	1.246	Mean difference = 0.48 p (2-tailed) = 0.083
	Afternoon	36	3.81	1.283	
Inference	Morning	53	6.38	2.388	Mean difference = 0.46 p (2-tailed) = 0.325
	Afternoon	36	5.92	1.746	
Evaluation & Explanation	Morning	53	3.55	1.422	Mean difference = 0.27 p (2-tailed) = 0.404
	Afternoon	36	3.28	1.579	
Induction	Morning	53	7.13	2.254	Mean difference = 0.38 p (2-tailed) = 0.462
	Afternoon	36	6.75	2.590	
Deduction	Morning	53	7.08	2.637	Mean difference = 0.83 p (2-tailed) = 0.109
	Afternoon	36	6.25	1.873	

5.3.3.2 Questionnaire on Critical Thinking Skills

Students' Reflections on the Improvement of Their Critical Thinking Skills

The questionnaire administered to the students at the end of the semester also included seven questions on critical thinking skills. The students were asked to evaluate to what extent their thinking skills had improved after this Optics Course in a Likert scale (*not at all, a little bit, somewhat, very much* and *exceedingly*). The critical thinking skills mentioned in these questions consist of interpretation, analysis, evaluation, interference, explanation, inductive reasoning and deductive reasoning. Cronbach's alpha reliability coefficient of the seven items measuring critical thinking skills was 0.872 - high reliability (Cohen et al., 2011). Findings from the students' self-evaluation on the improvement of their critical thinking skills will be presented in the following figures.

Figure 5.17 describes the frequency of the students' answers to the question about the critical thinking – interpretation. Most of students (75 out of 85 students – 88%) believed that their interpretation skills had improved either *somewhat*, *very much* or *exceedingly*. Eight students thought that this thinking skill had improved *a little bit*, and two students said *not at all*.

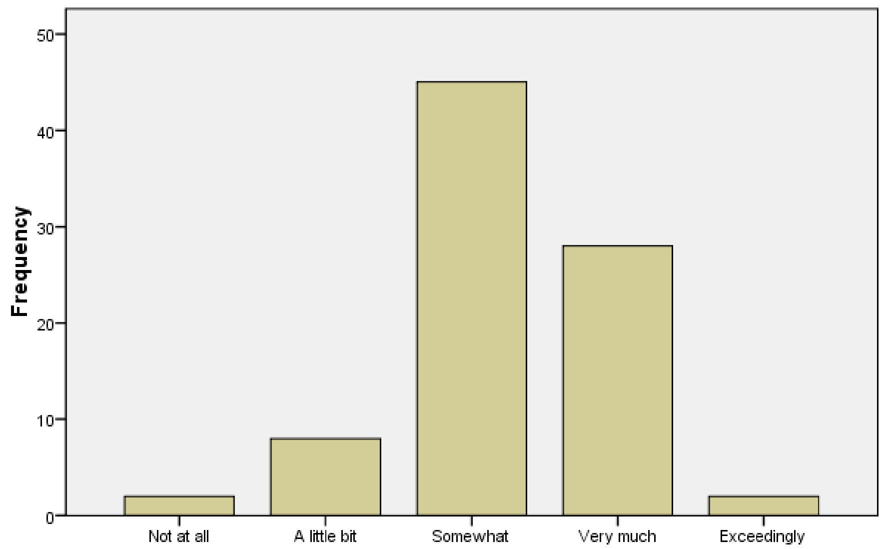

Figure 5.17 Critical thinking skill – interpretation

For the analysis skill, all of the students (86 students) believed that their thinking skill had improved at some extent, from *a little bit* to *exceedingly* (*Figure 5.18*). Forty two percent of the students stated that their analysis skill had improved *very much*; this number for the answer "*somewhat*" is 50%.

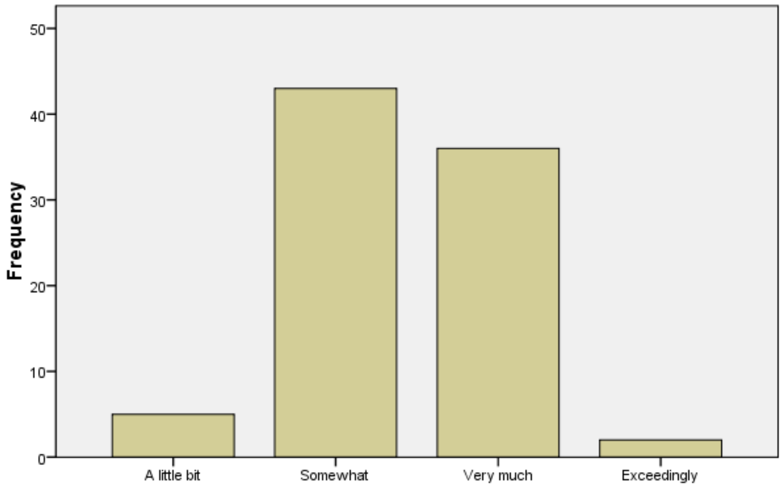

Figure 5.18 Critical thinking skill - analysis

Similar to the analysis skill, all of the students stated that their evaluation skill had improved at a certain extent after the Optics Course (*Figure 5.19*). The most popular answer is "*somewhat*" which was chosen by 53% of the students (46 students out of 87). The second popular answer is "*very much*" by 36% of the students.

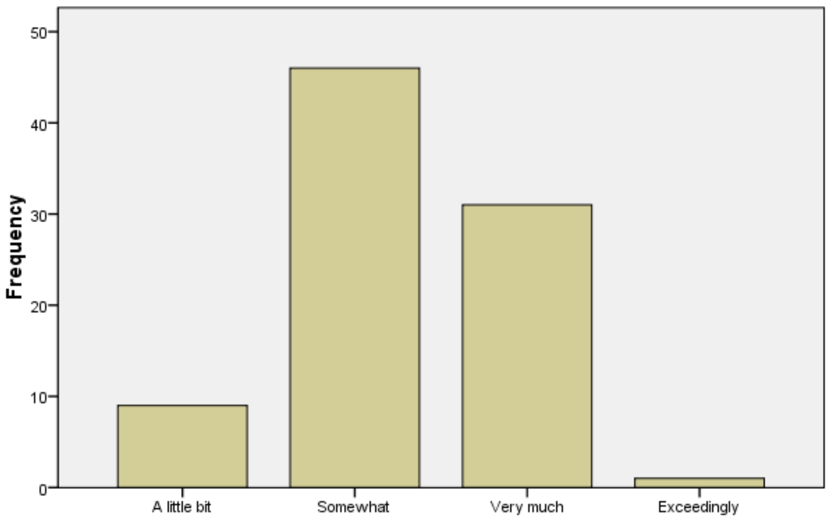

Figure 5.19 Critical thinking skill - evaluation

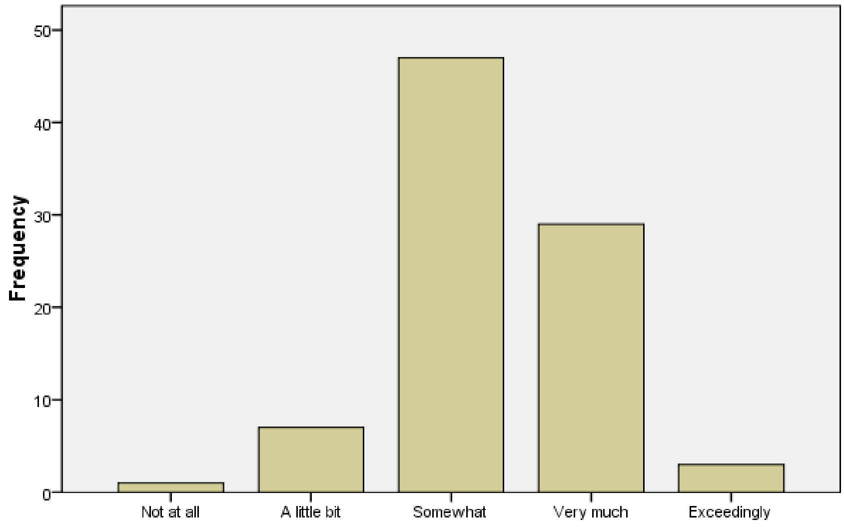

Figure 5.20 Critical thinking skill - inference

Figure 5.20 presents the result from the students' replies on to what extent they thought their inference skills had improved. Only 1% of the students (1 out of 87 students) said that their critical thinking skill had not improved at all. Most of the students believed that their inference skills had improved.

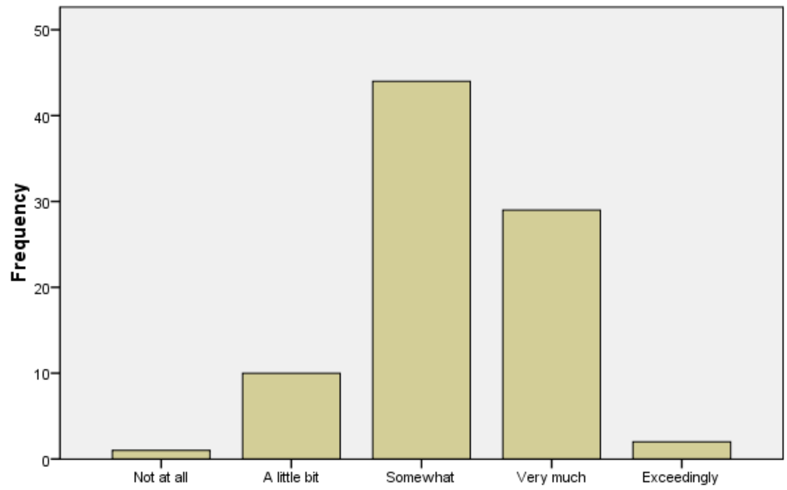

Figure 5.21 Critical thinking skill - explanation

Figure 5.21 also displays the same trend for the students' answers as *Figure 5.20*. Most of the students (85 out of 86 students) stated their explanation skills had been enhanced after the Optics Course. Of the students, 85 % confirmed this critical thinking skill had improved either *somewhat* or *very much*.

For inductive and deductive reasoning, a majority of the students believed that their skills had been enhanced either *very much* or *somewhat* (85% of students for inductive reasoning and 89% for deductive reasoning) (*Figure 5.22* and *Figure 5.23*). Few students believed these skills have improved *exceedingly*; about ten percent of the students answered "*a little bit*"

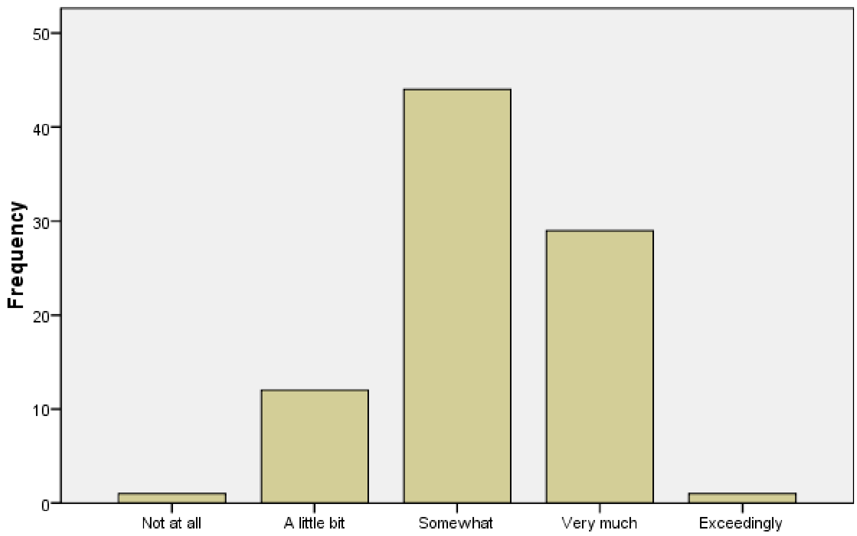

Figure 5.22 Critical thinking skill – inductive reasoning

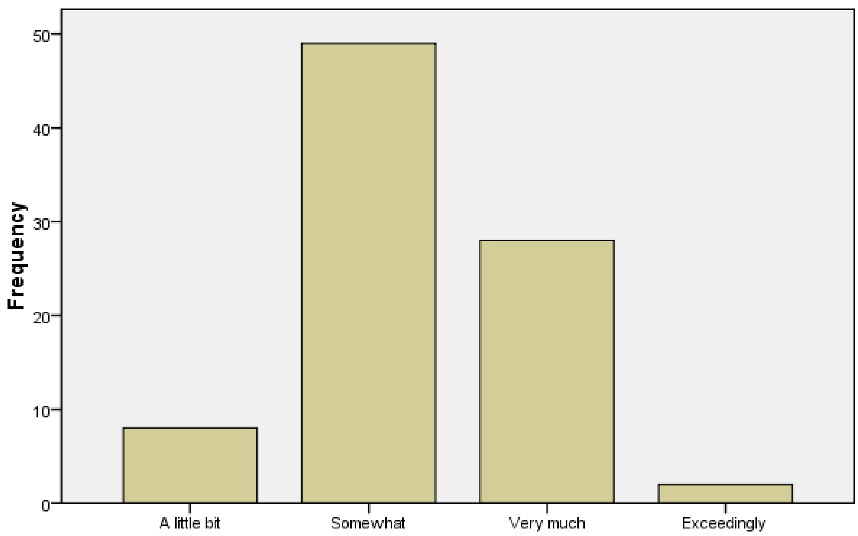

Figure 5.23 Critical thinking skill – deductive reasoning

In general, most of the students who participated in the research believed that their critical thinking skills had improved to a certain extent from *a little bit* to *exceedingly*. A majority of them said that their skills had improved *somewhat* or *very much*. Just a few students considered that their thinking skills had not been enhanced at all.

Comparing Morning Group to Afternoon Group

In the post-questionnaire, the students were requested to self-evaluate the improvement of their thinking skills in a five point Likert's scale. The students' answers in the Likert's scale were coded as: one for not at all, two for a little bit, three for somewhat, four for very much and five for exceedingly. There were two groups of students involved in this research and the treatment on the two groups was slightly different. Therefore, a comparison of students' self-evaluation on the improvement of their critical thinking skills between the two groups was conducted.

Table 5.20 displays t-test result of the students' self-evaluation on the improvement of their critical thinking skills - comparing Morning Group to Afternoon Group. The probability values in the table are larger than 0.05. This means that there are no significant differences between the Morning Group and the Afternoon Group in the scores of the students' self-evaluation on the improvement of their critical thinking skills.

Table 5.20 *Students' Self-evaluation on the Improvement of Their Critical Thinking Skills - Comparing Morning Group to Afternoon Group*

Thinking skills	Group	N	Mean	SD	Mean difference & p (2-tailed)
Interpretation	Morning	53	3.25	.782	Mean difference = .027 p (2-tailed) = .876
	Afternoon	32	3.22	.706	
Analysis	Morning	53	3.43	.694	Mean difference = .070 p (2-tailed) = .623
	Afternoon	33	3.36	.549	
Evaluation	Morning	54	3.30	.662	Mean difference = .054 p (2-tailed) = .714
	Afternoon	33	3.24	.663	
Inference	Morning	54	3.28	.787	Mean difference = -.056 p (2-tailed) = .728
	Afternoon	33	3.33	.595	
Explanation	Morning	53	3.23	.776	Mean difference = -.046 p (2-tailed) = .778
	Afternoon	33	3.27	.674	
Inductive reasoning	Morning	54	3.17	.746	Mean difference = -.076 p (2-tailed) = .641
	Afternoon	33	3.24	.708	
Deductive reasoning	Morning	54	3.24	.642	Mean difference = -.093 p (2-tailed) = .528
	Afternoon	33	3.33	.692	

5.4 Triangulation

To support triangulation, data was collected by different methods (e.g. observations, optics tests, critical thinking skills tests, interviews and surveys) and from different groups of people (the students, the lecturer, the teaching assistant and the two observers). This way of collecting data helped to confirm the influence of the CSI Model on the students' learning (i.e. the interaction within the learning environment, the students' optics performance and critical thinking) from different perspectives and provide a more thorough understanding of the influence of the model.

Chapter one defined the criteria which helped to identify if the model is an effective pedagogic model. This section will discuss the influence of the CSI Model according to these criteria which relate to interaction within a learning environment, students' optics learning and their critical thinking skills.

5.4.1 Interaction within the Learning Environment

As mentioned in Section 5.3, quantitative data collection methods (i.e. the scores of the two observers on the interaction degree and the student questionnaires) were the main data collection methods to help investigate the interaction within the learning environment. The qualitative data collection methods (i.e. the students' interviews, the interviews with the lecturer and the teaching assistant) were also used to support the quantitative methods. Findings from both quantitative and qualitative methods disclosed an understanding of the interaction from different perspectives which contributed to the whole picture of the interaction within the learning environment. This picture has three striking features: the interaction degree, the types of interaction and the differences between interactions in this Optics Course and other courses.

The Interaction Degree

As presented in Section 5.3.1.1, the two observers scored interaction degrees in the classes. Findings from the observations show that interaction degrees inside classes of both Morning Group and Afternoon Group at the end of the semester (week 13) were significantly higher than those at the beginning of the semester (week 3). Similar to the Morning Group, the interaction degree inside the Afternoon Group classes in week 13 is significantly higher than those in week 3.

The findings from the interviews with the lecturer and the teaching assistant are consistent with the findings from the observers' scores. It is revealed from these interviews that the lecturer concentrated on fostering interaction within the learning environment, both inside and outside class. For interaction outside the classes, the lecturer designed weekly learning tasks which required students to work in groups, study optics topics from different resources (e.g. textbooks, books and online resources), discuss and design presentations to explain the topics to their peers in class. For interaction inside class, he focussed on learning activities such as students' presenting and explaining optics topics to their peers and students' sharing solutions for optics assignments. He stimulated students to ask questions and engaged them in discussion. He believed that as a result, the interactions both inside and outside of the class were enhanced. The observations of the interaction degrees during class at the end of the semester were statistically significantly higher than the interaction degrees at the beginning of the semester, in line with the lecturer's intent and beliefs for the class.

Interviews with students confirmed the above findings. The students indicated that the interaction degree increased during the semester. The student interviews also reveal that outside the class, the students worked in groups, discussed, conducted their group learning tasks given by the lecturer and shared workload. In the students' opinions, they were provided with opportunities to share ideas and actively participate in learning activities, including the learning activities on the LMS. To conduct the group learning tasks given by the lecturer (e.g. designing a

PowerPoint presentation to explain the optics topics to their peers), the students interacted with various learning resources. Besides traditional resources such as the textbook and books, the students sought information related to the optics topics on the internet. They worked in groups, looked for information and designed the presentations. The students reported that they usually used electronic media to discuss with their classmates and used these media to support doing group work. A finding that emerged from different data sources is that discussions and idea-sharing often occurred both inside and outside the classes when the students conducted their group work and accomplished their shared learning goals.

Types of Interaction

Data from student interviews and the post-questionnaire adds further insight into the interaction within the learning environment. *On the aspect of students-students interaction*, the interviewed students said that they discussed, explained optics topics and shared solutions for assignments with their classmates. This finding is consistent with the findings from the questionnaire. Students' responses to the questionnaire show that a majority of students said that they either sometimes or usually presented their ideas in the classes. The majority of them regularly contributed to class discussion and worked with their peers on tasks/assignments/projects in the optics classes. The students usually worked with classmates outside the class to carry out class assignments/projects/tasks and used electronic media to discuss with their classmates about academic issues.

On the aspect of students-teacher interaction, the data from the post-questionnaire shows that the lecturer answering questions from students and questioning them occurred frequently in the optics classes. The findings from the post-questionnaire are reinforced by student interviews. The interviewed students disclosed that in the optics classes, the students were given opportunities to discuss with the lecturer. Students reported that he often asked questions to help them think and construct their knowledge. According to the students, the lecturer created opportunities for them to share ideas and actively participate in learning activities both in class and on the LMS. The above disclosure from the students is consistent with what the lecturer said: he tried to foster interaction within the learning environment.

Furthermore, data from the questionnaire reveals an insight which the data from interviews with students and the lecturer as well as the data from observations have not covered. Although the students were often involved in discussions with the lecturer inside the class, the frequency of using electronic medium to communicate with him outside the class is not high.

On the aspect of students-learning resources interaction, the lecturer and the teaching assistant believed that because of the requirement of the lecturer, the students worked hard, read learning materials and completed the given learning tasks. The interviewed students confirmed the opinion of the lecturer and the teaching assistant: while conducting their group learning tasks, they read many learning materials to research the optics topics.

These findings from different sources of data including interviews with the lecturer and the students as well as from the student questionnaire provide us with an understanding of interactions between students and learning resources in this learning environment. The lecturer aimed to enhance interaction between the students and a wide range of learning resources. He and the tutor believed that this aim had been achieved. The results from the student interviews and the student questionnaire show that the students interacted with a variety of resources, especially online.

However, answers to one question in the student questionnaire indicate a different result. In the questionnaire, item B8 on how often the students '*worked* ***on a paper or project*** *that required integrating ideas or information from various sources*' focussed on interaction outside the class. The aim of this item was to investigate whether the students integrated ideas and information from various resources when they conducted learning tasks. More than half of the students' responses (67%) to the item were in the three categories *not at all, once per semester* and *once a month.* This seems to contrast with the findings from student interviews: the students studied different learning resources (e.g. the lecture notes, books and online resources) in order to complete their learning tasks – making an optics presentation.

This contradiction in the results of the two data sources may be due to the way this item was written in the questionnaire. The item was aimed to investigate how often the students used information from a range of resources to carry out *a learning task*. Nevertheless, the words '*a paper or project*' appeared to be too specific to reflect '*a learning task*'. '*A paper or project*', which was used in the item, was probably considered by the students as different from the optics presentations they had made. Therefore this question may not measure what it was aimed to measure. It seems that the responses to this question do not represent the frequency of students integrating ideas or information from various sources when they worked on *a learning task*.

Insights of the interactions occurring in this learning environment provide us with some understandings of the influences of the CSI Model on the interactions. The implementation of this model made some differences, and the degrees of interactions increased during the semester. To get deeper understanding of the influences of the CSI Model, a comparison between this Optics Course and other courses could be useful.

Students' Perspectives on the Differences of Interaction in this Optics Course and Other Courses

Data from student interviews reveals that this Optics Course was perceived to be more interactive than other courses that the students had studied. The interviewed students said that teachers in other courses usually gave lectures, and the students did not have many opportunities to talk, discuss or present their ideas.

This finding is also confirmed and clarified by the findings from students' questionnaires. T-test was performed to identify the differences in the frequencies of activities reflecting interactions between the Optics Course and other courses. The results show that the frequencies of these activities in the Optics Course are higher than those in the other courses.

Among the twelve activities, the differences in the frequencies of five activities are statistically significant. These activities are (B1) instructor asking questions, (B2) instructor answering questions , (B5) students making class presentations, (B6) students working with classmates on tasks/assignments/projects inside the class, and (B 12) students using electronic medium to support doing group work.

The seventh item (B7) focusses on how often students come to class without completing readings or assignments. The average frequency of this activity in the Optics-Course is a little higher than that in the other-courses (Mean difference = 0.045, p (1-tailed) = 0.346). Although the difference in the frequencies is *not statistically significant*, the mean difference may hold a clue that the students coming to these optics classes without completing readings or assignments is slightly more regular than they coming to the other classes.

One possible reason could be that students were given more learning tasks at home in this Optics Course than they were in the other courses. As a result, they more regularly come to classes without completing the tasks. The student interviews revealed that students needed to do lots of reading and many learning tasks including assignments before going to optics classes. According to the students, they needed to invest a lot of time outside the class to study optics. One student even complained that studying optics at home occupied the majority of his time.

In summary, different sources of data were collected to support examining the influences of the CSI model on the interaction within the learning environment. These sources included scores on interaction degrees in the classes given by two observers, students' questionnaires, interviews with the students as well as interviews with the lecturer and the tutors. The data collected from different sources helps to triangulate the findings and provide us with a more accurate and bigger picture of interactions in this learning environment. Implementing the CSI Model, the lecturer aimed at enhancing interactions in the learning environment. Findings from the observers' scores, the lecturer and tutor interviews, the student interviews as well as the questionnaires suggest that interactions both inside and outside the classes were fostered and was perceived to be enhanced during the semester. Moreover, the students believe that the interactions in this Optics Courses are higher than the interactions in the other courses that they have studied in the previous semester.

5.4.2 The Students' Optics Learning

The optics test results show that the students' post-test scores are statistically significantly higher than their pre-test scores. The findings from students' interviews, student questionnaires and the interviews with the lecturer and the teaching assistant explain the results of the optics tests.

According to the lecturer, in this Optics Courses, instead of transmitting optics knowledge by lectures as in previous years, he tried to facilitate the students to discover optics by themselves. He requested the students to research and present optics topics. Interviews with the students confirm and complement the lecturer's views. The students noted that they were engaged in learning. They researched the optics topics in advance by searching information from different websites, books and the textbook. It is shown from the student interviews that the students used different sources of information when they studied and tried to make sense of the optics topics.

The students also believed that during the course they became more active and independent in learning. Their skills such as ICT skills, skills of seeking information, presenting and explaining ideas were developed. These beliefs of the students about themselves are confirmed by the lecturer's and the teaching assistant's opinions. They stated that the students became more confident, motivated, dynamic and active in learning. The lecturer and the teaching assistant also noted that the students' skills in presenting and explaining optics topics were improving during the course.

5.4.3 Students' Critical Thinking Skills

The students' critical thinking skills were assessed by the California Critical Thinking Skills Test at the beginning and at the end of the semesters. The results of the tests show that, the students' critical thinking skill scores at the end of the semester are statistically significantly higher than those at the beginning of the semester.

The students were also asked to self-evaluate the improvement of their critical thinking skills after studying the Optics Course. The students' self-evaluation confirmed the critical thinking test results. Most of the students stated that their critical thinking skills had been improved after this Optics Course.

5.5 Chapter Summary

This chapter presented the findings from the range of data sources. First, a description of the implementation of the CSI Model was provided. At the beginning of the semester when the CSI was first implemented, the students were not highly engaged in their learning. Many of them did not carry out the learning tasks given by the lecturers. The implementation of the model appeared to result in some changes in students' learning. These changes were revealed from the interview data presented in the second section and from the quantitative data presented in the third section.

The second section presented the findings from the interviews with the lecturer, teaching assistant and students. Four main themes emerged from the lecturer's and the teaching assistant's interviews data:

- the lecturer fostered interaction within the learning environment;
- students engaged more in learning and became more active and independent;
- the key factor of the change was the implementation of the CSI Model; and
- it was a new way of teaching and learning for both the lecturer and the students.

The findings from the students' interviews revealed five key themes. The way this Optics Course was taught:

- was considered as a good way of teaching,
- made learning optics fun,
- provided high degree of interaction,
- helped enhance physics learning,
- utilised ICT to support learning, and
- had some weaknesses, including time consuming for students.

The third section focused on the findings from quantitative data. The students' results of the optics tests and critical thinking skills tests showed that there were statistically significant differences in the students' test scores. On average, the students' post-test scores were higher than their pre-test scores. Data from the observation schemes, where the two observers rated the degree of interaction inside the class on a scale of one to ten, disclosed that the degree of interaction within this learning environment increased modestly but significantly over the semester. The findings from the students' questionnaire, which was administered to 89 students at the end of the semester, showed the students' self-evaluation of the interaction inside and outside the class, and the change in their level of critical thinking skills. The students reported that the lecturer asking and answering questions from students occurred 'often' in the class. Outside the class, the students usually worked with their classmates to prepare assignments/learning tasks, used electronic media to discuss academic issues with classmates and to support group assignments/tasks. Most of the students believed that their critical thinking skills had improved during the Optics Course. More than 80% of the students revealed that their thinking skills improved either *very much* or *somewhat*.

The fourth section discussed triangulation among the data sources. The discussion related to the interaction within the learning environment (e.g. the interaction degree, the types of interaction and the differences between interaction in this Optics Course and other courses). The discussion also focussed on the students' optics learning and critical thinking skills.

Chapter 6 Discussion

Chapter 5 is structured on the basis of the data sources which comprise the lecturer and the teaching assistant interviews, the student interviews, the optics tests, the critical thinking skills tests, the observations and the student questionnaires. Based on the findings from these data sources, the current chapter will integrate these findings to address the three research questions. The three research questions are:

1. In what ways does the application of the pedagogic model increase interaction within the learning environment?

2. Does the application of the pedagogic model improve students' physics test results?

3. In what ways does the application of the pedagogic model enhance students' critical thinking skills?

As described in Section 3.6 of Chapter three, data from different sources was used to investigate each research question. This supports triangulating and enriching the data, and as a result, provides a more accurate and wider understanding of the influences of the CSI Model. This chapter will also include a discussion of the CSI Model. In the discussion, the relationships between ICT, the learning principles and students' learning will be specifically addressed. Furthermore, the results of this study will be related to other literature in order to examine to what extent they are consistent and different from the results of other studies.

6.1 The Application of the CSI Model and Interaction within the Learning Environment

As illustrated in Table 3.2 of Chapter three, to investigate the influences of the CSI Model on interactions within the learning environment, different data collection methods including observations, survey and interviews were utilised. Furthermore, the data was collected from different groups of people such as observers, students, the lecturer and the teaching assistant, who viewed the influences of the CSI Model from different perspectives. The findings from these sources will be discussed in this section. Triangulation between the findings from different data sources will serve to examine to what extent these findings confirm, contradict and complement each other. Moreover, the triangulation between data sources helps to obtain a more precise and broader comprehension about interaction within this learning environment.

This section will begin with a discussion on fostering interaction and will end with a comparison of interactions in the Optics Course and other courses, and a summary.

6.1.1 Fostering Interaction

Pham (2008) argues that Vietnam is one of the countries heavily influenced by Confucian philosophy, and as a result, the relationship between teachers and students is highly hierarchical. In this relationship, students must obey and listen to teachers. According to Pham, the Confucian influence leads to the issue that Vietnamese students tend to behave as passive listeners in classes, and a learning style including cooperation and interaction is not suitable for Vietnamese students (Pham, 2008).

The previous-year students, who had not experienced the implementation of the CSI Model, were passive in their learning. They tended to sit quietly and listen to the lectures, without engaging, even superficially, in learning activities and discussion. This is consistent with Pham's perception of the nature of Vietnamese students.

When the current students started to experience the implementation of the model at the beginning of the semester, they were not active, either. The lecturer needed to be persistent in influencing and creating new learning habits in the students. The students gradually became more engaged with the learning tasks and activities. They progressively ended up being hard-working in doing group assignments, searching and reading learning resources, as well as thoroughly preparing for the presentations that they used to explain optics to their classmates. They also gradually became more engaged in discussions inside class.

One result of the current study is that Pham's argument, that as a consequence of Confucian influence, a learning style which contains cooperation and interaction appears not to suit Vietnamese students (Pham, 2008), is not necessarily the case. The findings of this study seem to illustrate that with teachers' intention, guidance, support and carefully designed learning tasks, students do engage with cooperative and interactive learning tasks.

6.1.2 More Insight into Interactions

Ng and Nguyen (2006) and Stephen et al. (2006) state that in Vietnamese classrooms, the students tend to passively sit, take notes and listen rather than discuss and present their ideas. In contrast, the current study shows that these Optics classrooms are rather interactive.

On the aspect of students-students interaction, the students participating in this research regularly discussed, exchanged ideas, explained optics topics and shared solutions for assignments with their classmates. These activities of the students reflect the learning principle which is presented in the social aspect of the CSI Model (Section 4.2.2): that learning occurs in social contexts. This sociocultural learning principle is based on the notion that knowledge is distributed among people, artifacts, environments and situations (Pea, 1997; Salomon & Perkins, 1996; Salomon & Perkins, 1998). Students acquire knowledge and skills when they participate in socially organised activities, work in groups and accomplish shared goals (Cobb & Bowers, 1999; Greeno, 1997; Salomon & Perkins, 1998). In this Optics Course, the students interacted with others and worked in groups to accomplish learning tasks. During this process, they cooperated and co-constructed their knowledge and skills.

The sociocultural learning principle of the CSI Model (*Figure 4.3*), that learning occurs in social contexts, is also reflected in the students-teacher interaction in this Optic Course. The students were frequently asked questions by the lecturer as well as given opportunities to discuss, share ideas and participate in learning activities. They also frequently asked questions in the classes, even when unprompted by the lecturer to do so. The lecturer in this case played the role of a social agent facilitating students' learning as described by Salomon and Perkins (1998). With the designed learning tasks, guidance, feedback, encouragement and series of systematic questions, the optics lecturer appeared to help the students achieve development in their learning which is beyond the level of development that individual students can achieve when they work alone. The students' development in their learning will be discussed more in depth in Section 6.20.

In this Optics Course, the students tended to use ICT as a tool to discuss issues with their classmates outside the classes more frequently than with Mr. Van. This may be explained by the fact that the learning tasks required students to discuss online with their peers more regularly than to communicate with the lecturer. Another reason is probably related to the lecturer's competency in using ICT. The lecturer noted that his ability in using ICT was quite limited compared to the students', and this may have led to his more limited use of electronic media to support communication than the students'.

On the aspect of students – learning resources interaction, one of the lecturer's goals when he designed the learning tasks was to encourage students to interact with a wide range of learning resources such as the textbook, books and online resources, rather than traditionally with the textbook only. While engaged in the group learning tasks, the students studied a range of learning materials to research the optics topics. The learning materials included books, lecture notes and rich online resources, and most of the students used electronic media to support their group's tasks. Pea (1997) states that knowledge is constructed by utilising artifacts to accomplish activities' goals. When the students in this Optics Course accomplished their group learning tasks, they co-constructed their knowledge by utilising the variety of learning resources including online resources.

The students believed that this Optics Course was more interactive than other courses that they had studied. The traditional approach in other courses is for the teachers to give lectures. The students are not provided with many opportunities to talk, discuss or present their ideas.

On one hand, this students' view about other courses seems to be consistent with the results of studies conducted by Ng and Nguyen (2006) and Stephen et al. (2006): students passively sit, take notes and listen. On the other hand, the interactive learning enviroment in this Optics course indicates that the findings from Ng and Nguyen (2006) and Stephen et al. (2006) are not necessary the case.

6.2 The Application of the CSI Model and the Students Optics Learning

The above section addresses the first research question which relates to the interactions within the learning environment. This section will discuss the second research question: 'Does the application of the pedagogic model improve students' optics test result?'. The discussion will not only concentrate on a specific answer of this question but also more broadly consider the influence of the CSI Model on the students' optics learning. As presented in Table 3.2 of Chapter three, data which is collected by two different methods (i.e. optics tests and interviews) and from different people (i.e. students, the lecturer and the teaching assistant), helps investigate this second research question. The discussion will be organised into three sub-sections. The first two sub-sections focus on two themes, a new way of teaching and learning physics, and the enhancement of optics learning. Finally, the third section will discuss the indicators of the students' deep learning.

6.2.1 A New Way of Teaching and Learning Physics

The Student-centred Approach

The CSI Model was implemented in the Optics Course for one semester. The lecturer of the Optics Course believed that implementation of this pedagogic model offered opportunities for new ways of teaching and learning to be implemented. It appeared that the lecturer had been moving toward a student-centred approach, the characteristics of which are identified by Pham (2010) in Table 1.4:

- A teacher works as facilitators of learning, selects and divides lessons for group work
- A student actively involves in one's own learning and in learning processes of peers

The spirit of the student-centred approach is also presented by Pithers and Soden (2000) as "The teacher-centred orientation includes conceptions that teaching is about imparting information or transmitting structured knowledge, whereas the student-centred orientation includes beliefs that teaching is about facilitating understandings, promoting conceptual change and intellectual development" (Pithers & Soden, 2000, p. 247).

In this Optics Course, instead of transmitting optics knowledge by lectures as in the previous years, the lecturer tried to facilitate the students so that they discovered optics by themselves. He asked the students to research the optics topics and present the topics in class. He focussed on students' learning activities both inside and outside the classes. The lecturer tried to engage them in learning and helped them learn actively. The role of the lecturer shifted from the one delivering knowledge to more of a guide, a facilitator and an organiser.

In other courses, and traditionally in this course, teachers' lecturing occupied most of the time while students' presentations, discussion and idea-sharing hardly occurred at all, so the teacher-centred approach is likely to dominate in the other courses the students have studied. This is consistent with the consensus of previous studies: that the teaching approach in Vietnamese classes is traditionally teacher-centred (Ng & Nguyen, 2006; C. Nguyen, 2012; Saito et al., 2008; Stephen et al., 2006). In contrast with other courses that the students have experienced, the teaching approach in the Optics Course was more student-centred. The students in most cases commented that they appreciated the Optics Course because of the way it was taught; they were given the learning tasks which required researching optics topics in advance. The students valued the teaching strategies: they were requested to present the optics topics, discuss, and contribute to the lessons. The lecturer believed that the students had not experienced this way of learning before.

The teaching approach in this Optics Course is student-centred while it is stated by Stephen et al. (2006), Ng and Nguyen (2006), C. Nguyen (2012) and Saito et al. (2008) that the traditional teacher-centred approach dominates in Vietnamese classrooms. This indicates that the CSI Model, which was implemented into this course, may contribute to Vietnam’s education a new model of teaching and learning Physics. The implementation of this pedagogic model aligns with the educational policy of Vietnam in promoting a student-centred approach ("Nghị quyết 14/2005/NQ-CP về đổi mới cơ bản và toàn diện giáo dục đại học Việt Nam giai đoạn 2006 - 2020 [The resolution no. 14/2005/NQ-CP on fundermental and comprehensive higher education reform in Vietnam for the period of 2006 – 2020] (Vietnam)," 2005).

The Divergent Views of the Students

Since this is a new way of teaching and learning, students' opinions of the way the Optics Course was taught were divergent. Most of the interviewed students stated that they liked this way of teaching and gave many complements about the course. Many students said that due to the requirements of this course, they had invested lots of time to the study of optics, which indicates that the students were engaged in learning. However, a small number of students complained that they spent too much time studying optics and so did not have enough time to do other things. Many students considered this way of teaching to be excellent, but a few students preferred the traditional way of teaching: teachers gave lectures, and students listened and took notes. These students believed that the knowledge presented by teachers was absolutely correct, and the knowledge that they constructed might not be accurate.

This view of these few students could be partially explained by the finding of the previous research that Vietnam's education is strongly influenced by a Confucian tradition (C. Nguyen, 2012; H. P. Nguyen, 1974). Ellis (1994) argues that teaching and learning in Vietnam under the influence of a Confucian philosophy is teacher-centred. Teachers have a highly respected status in society, and so have a superior position in classrooms and are greatly trusted by students (Ellis, 1994; C. Nguyen, 2012). Thus, the students prefer to put their complete trust in the teachers and the teachers' knowledge rather than the knowledge they constructed together with their peers.

According to Pham (2008), Vietnamese students under the influence of Confucian philosophy tend to regard their teachers as knowledge deliverers, and the students are not familiar with asking questions and engaging in active learning. When the new teaching and learning model was implemented, a few students preferred the traditional way of teaching. This could reflect the normal trend of reactions of the students whose learning stems from Confucian tradition, but there was no direct evidence in the data from the study to support this conclusion.

In this Optics Course, a few students felt uncomfortable with the new way of teaching and learning and preferred the traditional way. In contrast, most students started exercising their student-centred role, gradually taking control of their learning process, enjoying the greater autonomy and co-constructing their knowledge with the support, guidance and scaffolding of the teacher. Although there were different views of the students toward the way of the Optics Course was taught (i.e. a majority of the students greatly appreciated this teaching way, a few did not), this way of teaching helped enhance their optics learning.

6.2.2 The Enhancement of Optics Learning

The results of previous studies indicate that ICT can be used to effectively support students' learning (Driver, 1988; Kamali-Mohammadzadeh et al., 2014; Ojugo et al., 2013; Ozkal et al., 2009; Rovai, 2004). The use of ICT is underpinned by the CSI Model in the current study. Its findings that the students' learning was enhanced confirm the results of the previous studies. The students' enhancement in optics learning was indicated by their optics test results and their learning activities during the semester.

The students' optics test scores indicated that their learning was enhanced. Their post-test scores were significantly higher than their pre-test scores. The comparison between the optics test scores of the current semester and those of the previous semester when the CSI was not implemented also added support for this effectiveness: the test scores of the students who experienced the CSI implementation were significantly higher than the test scores of those who did not.

In addition, while the CSI Model was implemented into the Optics Course for a semester, the degree of ICT application in the two groups was different. The degree of ICT applications to support learning in the Morning Group was higher than in the Afternoon Group. The Morning Group used the online learning management system LMS to support their learning. This LMS allowed these students to upload and share their learning material including PowerPoint slides and to communicate and discuss online. The Afternoon Group did not use the LMS at all. The students of the Morning Group and the Afternoon Group took the same optics test at the beginning and at the end of the semester. The test results of the two groups show that:

- The students' post-test scores are statistically significantly higher than their pre-test scores. This result applies for both the Morning and Afternoon group.
- At the beginning of the semester, there is no significant difference between the test scores of the two groups.
- At the end of the semester, the test scores of the Morning Group were significantly higher than the test scores of the Afternoon Group.

The above results suggest that ICT is a useful tool to enhance students' physics learning and students' physics performance, which confirm the findings of the earlier work by Christina and Dimitrios (2008), Wang (2009) and (Driver & Scott, 1996).

Moreover, it is indicated from the findings that the students who experienced a higher degree of ICT applications in the light of the CSI Model implementation tended to perform better in the optics test than the students who used less ICT. In this research, the students in the Morning Group used more applications of ICT to support their learning (used an online management system). The students in the Afternoon Group used less applications of ICT to support learning (did not use an online management system). The use of ICT in both groups was of course underpinned by the CSI Model. At the end of the semester, the score of the students, who used ICT at the highest degree, (the Morning Group) is statistically significantly higher than the score of the students who used ICT at lower degree (the Afternoon Group).

As presented in Chapter five, the students of the Semester I Group did not experience the implementation of the CSI Model at all. The average test score of this group is significantly lower than the average scores of the Morning and the Afternoon Groups. No claim is made based on this result. It is because there is no solid evidence (e.g. pre-test results) showing that at the beginning of the semesters, these students were similar to the students of Morning and Afternoon Groups in term of Optics test scores. However, the statistically significant difference and the very strong effect size that were presented in Section 5.3.2 of Chapter five add some weight to the effectiveness of the implementation of the CSI Model and the students' optics scores.

The students' enhanced learning was indicated by their learning activities during the semester. The students were engaged deeply in learning. They researched the optics topics in advance by searching information from different websites, books and the textbook. They engaged in group work and assignments, shared the workload, discussed and prepared group presentations on optics topics. They shared their knowledge in class with MS PowerPoint presentations, explained the optics topics, asked and answered questions, discussed and commented. The students believed that this way of teaching helped them to comprehend the optics lessons more easily and faster, as well as obtain deeper and richer understandings of optics. In addition, studying optics for these students was fun, exciting and joyful. A student said:

> PowerPoint presentations help students study more easily, help reviewing relax and enjoyably, help learning more surprising and exciting. (SI_AGW15_18)

Furthermore, the students became more active and independent in their learning. Their skills such as ICT skills, skills of seeking information, presenting and explaining ideas were developed. They also became more confident, motivated, dynamic and active in their learning. In addition, their skills in presenting and explaining optics topics were improving during the course.

6.2.3 Deep Learning Indications

C. Nguyen (2012) argues that the learning styles of Vietnamese students are strongly influenced by Confucian beliefs; therefore, the students tend to take a surface learning approach to their studies. However, the findings from this research present a range of signs from the students' learning which may indicate occurrences of deep learning. Conditions and signs of a deep learning approach have been identified by previous studies (Biggs, 1987; Chin & Brown, 2000; Marton, 1983; Schmeck, 1988; Schmeck & Geisler-Brenstein, 1989; Schmeck, Geisler - Brenstein, & Cercy, 1991) and include:

- Understanding deeply the knowledge,

- Personalising the knowledge and tasks, and making them meaningful to the students' experience and their work in the future,
- Using several sources to study to make sense of a topic or a concept,
- Being independent and active in learning,
- Being interested in learning and enjoying studying optics.

Deep understanding of knowledge is an indication of deep learning (Biggs, 1987; Chin & Brown, 2000; Schmeck & Geisler-Brenstein, 1989). The students who participated in this research believed that the way the Optics Course was taught helped them to develop a deep understanding of the optics topics. Students' deep understanding of optics knowledge is supported by the optics post-test results. The students who experienced implementation of the CSI Model and the use of ICT at the highest degree (i.e. the Morning Group students) generally got high scores (mean score = 72%) in the optics post-test. The levels of the students' optics understandings are reflected by their test scores.

One more sign of the students' deep learning, which is identified by Biggs (1987) and Schmeck et al. (1991) and emerges from this research, is the personalisation of the learning tasks to make them meaningful to the students' experience and their work in the future. An example is illustrated by the description from a student on how useful the knowledge and skills that she learnt were to her future job as a teacher at a high school. The student said that in the Optics Course, the lecturer guided her to find knowledge. This helped her know how to find learning resources by herself and become independent in learning. When she graduates from the university and teaches at a high school, the lecturer will not be there to show her the resources that she needs for her teaching. But the student believed that she would be able to find them by herself because she had learnt how in this course.

The students used a range of different sources of information when they studied the optics topics, which another possible indicator of deep learning (Schmeck et al. (1991). For instance, a student, who was to become a high school teacher, described how he studied optics terms and definitions, before those terms and definitions were taught in the classes. The student said that in addition to the lecture notes, he used books and other learning resources (i.e. online resources). He did not only try to understand the terms and definitions but also tried to find easy-to-understand explanations from the resources so that he could learn from the explanations and then explain the terms and definitions to other students.

Another condition for deep learning pointed out by Biggs (1987) and Schmeck et al. (1991) is that students are independent and active in their learning. The students who experienced the implementation of the CSI Model became more active and independent in their learning, by actively researching the optics topics, carefully reading the information from different resources, trying to understand the information and make it meaningful and useful for their presentations and their own experiences. The students' deep learning is also exemplified by how they conducted their learning tasks. When the students were given a group learning task, such as explaining optics concepts or making a presentation to explain an optics topic to their classmates, they took control of their learning. They brainstormed, divided the workload among the group members, worked individually on the task, combined the work, discussed and contributed to a final product. These learning activities indicate that the students were independent and active in their learning processes.

Furthermore, a majority of students seemed to be interested in and enjoyed studying optics. This is an indication of deep learning mentioned by Marton (1983) and Biggs (1987). The students appreciated the learning tasks given by the lecturer, worked on the tasks and showed their enthusiasm. When these students talked about studying optics and the way the Optics Course was taught, they used a variety of adjectives such as relaxing, enjoyable, surprising, fun, joyful and excellent.

Although signs of deep learning were evident by a majority of the students, some students seemed to engage at just a surface level. These signs are also identified by Biggs (1987). The first sign is that a few students considered the learning tasks as demands to be meet rather than good strategies to support their learning. They did not appreciate the lecturer asking the students to carry out group learning tasks and to present and explain optics topics to their peers. These students indicated that they preferred to have the lecturer deliver lectures in the classes, and they could have listened and taken notes. The second sign of surface learning was identified from a few students who worried about the time the learning tasks took. These students complained that the learning tasks took too much time, yet did not consider the time they were working on the tasks as learning time, and could not see that they would benefit from their learning.

In summary, although it is stated by C. Nguyen (2012) that Vietnamese students' learning tends to be surface learning, the learning of the majority of students participating in this research showed indications of deep learning. Marton (1983), Biggs (1987), Chin and Brown (2000) argue that students adopt their learning approaches (surface vs deep learning) based on personal and situational factors. In this research, the students experienced some situational factors which were not encountered by the majority of Vietnamese students. The situational factors consisted of the implementation of the CSI Model, the nature of the learning tasks and the methods of teaching. The differences in the situational factors impacting on the students may lead to the difference of the learning approaches that the students take: the majority of students participating in this research adopted deep learning while Vietnamese students generally adopt surface learning.

6.3 The Application of the CSI Model and Students' Thinking Skills

While Section 6.2 focussed on discussing the students' learning and the second research question, this section will concentrate on the third research question: *In what way does the application of the pedagogic model enhance students' critical thinking skills*? It was described in Table 3.2 of Chapter three that three data sources would be used to investigate this research question: California Critical Thinking Skill pre- and post- tests, a student questionnaire and interviews.

The total scores and the five sub-scores (analysis and interpretation, inference, evaluation and explanation, induction reasoning as well as deductive reasoning) in the critical thinking skills of the students in the post-test are significantly higher than those in the pre-test. In addition, most of the students evaluated themselves that their critical thinking skills had been improved after this Optics Course.

The increase of the students' critical thinking skills during the Optics Course may be explained by the views of Kurfiss (1988) and Halpern (1998). According to Halpern (1998), students' critical thinking developed while they conducted learning tasks involving the processing of rich sources of information. She argues that in this learning process, the students analyse and synthesise the information as well as decide which information is useful for them in the tasks. They also involve in making plans, discussing with their peers, being open-minded, reasoning and self-correcting. During the process, their critical thinking skills are fostered. The view of Halpern (1998) is similar to Kurfiss (1988) argument that, while teaching science, teachers can foster students' critical thinking skills by engaging them in scientific inquiry, investigation or reasoning. She argues that at university, lecturers usually present students with the products of their arguments or explanation in lectures, and so students seldom get to know the processes of investigating and forming arguments. Because critical thinking occurs during these processes rather than during the lecturers' presentation, if the teachers give the students tasks of investigating a phenomenon, topic or problem, and provide them with suitable guidance and support, the students' critical thinking skills will be enhanced. During the investigation processes, the students seek information resources, analyse, synthesise and compare information, and discover patterns. As a result of critical thinking, outcomes such as arguments, explanation, hypothesis or justification would be formed (Kurfiss, 1988).

The explanation of the increase of the students' critical thinking skills is supported by Pithers and Soden (2000). The authors argue that a student-centred approach tends to promote the development of students' critical thinking. Ten Dam and Volman (2004) also state that students' active contribution to their learning processes and making meaning is an important factor enhancing critical thinking skills. As discussed on Section 6.2.1, the teaching and learning approach in the Optics Course was based on student-centred principles, which may be one of the reasons why the students' critical thinking skills are enhanced. Tsui (1999) shares similar views with Pithers and Soden, Ten Dam and Volman, and notes that learning activities such as conducting group projects and doing presentations in the class positively relate to the improvement of students' critical thinking skills. The students in this research were regularly involved in the above learning activities, and so it is reasonable that their critical thinking is improved.

Moreover, the interactions between students - students and students – teacher is another reason why students' critical thinking improved. Empirical research confirms that instructional activities such as pertaining to activate the interactions between students-students and students-teacher, as well as to encourage the students explaining their insights are important for the enhancement of students' critical thinking skills (Ten Dam & Volman, 2004; Tsui, 1999). Astin (1993) states that students-students interaction, such as discussing the course content and conducting group work, has strong positive effects on students' critical thinking skills. Pithers and Soden (2000) consider interaction between students and teacher as one of the best ways to promote critical thinking of students. Pithers and Soden believe that technology-based learning could be considered helpful, but their especial focus is on fostering students' critical thinking by teacher-students dialogue and student scaffolding with a systematic series of questions. On the *Social aspect* of the CSI Model, ICT is considered as artifacts to promote interactions. As discussed earlier, the interactions seem to be well-promoted in the Optics Courses. It may be because of this reason; the students' critical thinking skills are increased.

6.4 Reflection on the CSI Model

Among the applications of ICT noted by Collis and Moonen (2001) (Table 2.2), the implementation of ICT in this Optics Course seems to focus on four main applications: distributed resources via the internet, software and technology tools supporting face-to-face lectures, a course management system – LMS and email system. The internet resources are used by the students as learning resources to support the optics learning and for presentations. Beside the traditional resources such as the textbooks, books and library resources, the students exploited the rich resources on websites which comprise texts, photos, diagrams and videos. For face-to-face lectures, software and technology tools are utilised by the students and the lecturer include MS PowerPoint, laptop computers and LCD projectors. Outside the classes, the LMS is used to support student learning. The electronic media are also used by the students for the purposes of discussing academic issues with their classmates and doing group work. The use of ICT in this Optics Course is underpinned by the CSI Model (*Figure 4.3*); thus, the above applications of ICT will be discussed under the lens of the CSI Model.

In the CSI Model, learning, from cognitive constructivist perspective, means creating and self-organising knowledge (Fosnot & Perry, 2005; Von Glasersfeld, 1989). In this Optics Course, the students learn by observing, experiencing, and making meaning. ICT, from this perspective, is considered as a tool to support learning individually. According to Jonassen et al. (1998), the students internalise more information through their visual sense than other senses. The visual aids such as photos, diagrams, videos and multiple online resources of information provide them with rich opportunities to observe optics phenomena, explore new optics concepts and make sense of the new knowledge by themselves. The use of ICT helps them internalise knowledge easily, and helps Optics learning become interesting.

It is also argued by Jonassen et al. (1998) that search engines are useful tools that support students to access and process information. According to the students participating in this research, the search engine Google is useful for them in searching for optics learning resources. Rich and diverse information relevant to the optics topics that the students need to investigate is located and listed in a form of links. The students can access different sources of information (i.e. websites) by clicking on the links. The rich optics online resources provide individual students with splendid opportunities to discover, make sense and construct their own knowledge. It is disclosed this research that the internet resources seem to be intensively used by the students as learning resources. During the processes of processing information in the optics websites, the students practise their thinking skills, including assessing and comparing the information.

Salomon (1998) states that ICT provides students with opportunities to construct their knowledge in particular symbol forms and organise the knowledge in particular structures. The students in this Optics Course use MS PowerPoint to design and present optics topics. It is a tool for the students to construct their optics knowledge and display the knowledge in symbol forms of words, diagrams and photos. The students also organise optics knowledge in their own structures, and the structures of the knowledge are shown in the presentation slides.

In the CSI Model, learning, from sociocultural perspective, occurs in social contexts (Pea, 1997; Salomon & Perkins, 1998). Knowledge is distributed across and among people, cultures, artifacts, environments and situations (Pea, 1997; Salomon & Perkins, 1996; Salomon & Perkins, 1998). By participating in learning activities, interacting with other people, artifacts and environment, students can co-construct their own knowledge (Cobb & Bowers, 1999; Greeno, 1997; Salomon & Perkins, 1998).

In this Optics Course, beside traditional resources such as the lecture notes and books, the students are guided to interact with unlimited online optics resources created by scientists, experts, lecturers, peers and communities. Moreover, for each optics topic, the relevant learning resources from different authors are listed on the LMS. The students can study these resources, examine the explanations and arguments from each resource, and make sense of the knowledge from these resources in the students' own context. The students appreciate the posted optics articles on the LMS, which associate with the optic topics and have been written by different authors. They also utilise different online resources when they research an optics topic and design a presentation. While looking for optics information online, the students needed to process rich and diverse information. Thus, the thinking skills such as analysing and comparing the information were practised. This may explained why their thinking skills were improved after attending the course. With the support of ICT used a learning resources, the students are provided with opportunities to interact with the learning resources, exploit these ICT artifacts to engage in a meaningful learning activities and co-construct knowledge (Pea, 1997; Salomon & Perkins, 1998).

The students in this research use different synchronous and asynchronous communication methods to help conduct group learning tasks. The ICT communication methods (e.g. e-mail, telephone, chat and forum discussion on the LMS) support the students to discuss, interact, negotiate and accomplish group works (i.e. optics assignments and optic presentations). Discussions of the optics topics among the students and the lecturer/ the teaching assitant also occur on the forum of the LMS. As noted by Jonassen et al. (1995), the power of ICT is based on its capabilities to enhance discussion and interaction. In the current research, this power appears to be revealed once more as artifacts which promote interaction and enhance learning.

To sum up, in this Optics Course, the students' learning tasks were organised so that they had to participate in social activities such as group-working (e.g. planning, dividing the working among group members, using ICT to find information and communicate with group members, and designing optics presentations), explaining optics topics to classmates using PowerPoint presentations and discussing with groups' members, the lecturer and the class. From a sociocultural view, " learning is participation in social practice" (Greeno, 1997, p. 9). When working on the learning tasks, the students interact with the learning resources, the lecturer and other students. Their knowledge emerges through these interactions (Salomon & Perkins, 1998). This may be the reason why the students' optics post-test scores are significantly higher than their pre-test scores, and the post-test scores of the Morning Group (who use more ICT) are significantly higher than those of the After Group (who use less ICT to support their learning). According to Greeno (1997), besides acquiring knowledge, students acquire the skills while they participate in learning activities. This research confirms Greeno's outlook. The implementation of ICT in the light of the CSI Model helped them develop necessary skills for learners including skills of working with computers, seeking for information, presenting and explaining ideas.

6.5 Chapter Summary

Discussion in this chapter focussed on the CSI Model and the three research questions which related to the interaction, the students' optics performance and critical thinking.

The first section of the chapter addressed the application of the CSI Model and the interaction within the learning environment. It is argued by Pham (2008) that Vietnamese education is strongly influenced by Confucian philosophy. Therefore, Vietnamese students are likely to be passive learners, and have a learning style in which interaction and cooperation is not common. In this research, the lecturer tried to exploit the applications of ICT, support the students and promote interaction within the learning environment. As a result, the interaction increased during the semester, and the interaction degrees in the optics classes at the end of the semester are significantly higher than those at the beginning of the semester. Interactions between students-students, students-lecturer and students-learning material happened regularly. A lot of discussions and cooperation among the students and the lecturer occurred in this learning environment.

The second section addressed the application of CSI Model and the students' optics learning. It is stated that the teaching approach in Vietnam is generally teacher-centred (Ng & Nguyen, 2006; C. Nguyen, 2012; Saito et al., 2008; Stephen et al., 2006). In contrast, the teaching approach in the Optics Course was student-centred. The students' learning was enhanced, and the enhancement is shown in the learning processes as well as in the improvement of their test scores. It is argued by C. Nguyen (2012) that Vietnamese students' learning approach is surface learning. In contrast, the findings of this research indicate that the majority of students' engaged in deep learning.

The third section discussed the application of the CSI Model and the students' thinking skills. The students' critical thinking skills at the end of the semester significantly improved in comparison with those at the beginning of the semester. This improvement could be explained by the following reasons. The students' critical thinking skills are enhanced when they perform learning activities which require accessing diverse data resources. The students' improvement in their thinking skills may be due to the student-centred teaching and learning approach that they experienced. Another reason for the improvement could be the interactions between students-students and the lecturer-students which occurred during the semester.

While the three sections above discussed the CSI Model from specific perspectives of the interactions, the students' learning and critical thinking, the last section reflected the findings of this research upon the CSI Model from a general perspective. The applications of ICT which are exploited in this Optics Course consist of online resources, email systems, a learning management system, electronic media supporting communication, MS PowerPoint, computers and LCD projectors. ICT is used by the students and the lecturer as tools to support individual learning, to promote interaction, and so enhance social learning.

This chapter addressed the discussion of the CSI Model and the research questions. In the next chapter, conclusions based on the results of this study will be drawn. In addition, limitations and recommendations will be suggested.

Chapter 7 Conclusion, Limitations and Recommendations

This thesis has narrated the journey of developing a pedagogic theoretical framework for integrating learning principles and ICT into teaching physics. It started by addressing the need for a theoretical framework in response to two issues that have emerged within Vietnam's education context:

- The Vietnamese Ministry of Education & Training is leading an education reform aimed at changing teaching approaches from teacher-centred to student-centred. As a policy of the ministry, information communication technologies are becoming integrated in education. Regardless of the effort and money invested into technology and the reform, the teaching approach in Vietnam remains generally teacher-centred, and the Vietnamese learning environment is not interactive.
- One aspect of student-centeredness is critical thinking. While students' critical thinking skills are a great concern for education in many countries around the world generally and in ASEAN specifically, Vietnam's education is not focussed on the thinking skills of students. It is reported that Vietnamese students lack critical thinking skills (C. Nguyen, 2012; Stephen et al., 2006).

Based on the need and the issues above, the research goal and the questions were identified. The goal of the research was to develop, trial and evaluate a pedagogic model which integrates appropriate learning principles with ICT for the teaching of Physics in the context of Vietnam. In order to investigate whether the developed pedagogic model is effective and appropriate for the context, the following three research questions were used to examine the effectiveness of the model.

1. In what ways does the application of the pedagogic model increase interaction within the learning environment?

2. Does the application of the pedagogic model improve students' physics test results?

3. In what ways does the application of the pedagogic model enhance students' critical thinking skills?

The thesis then continued narrating the journey by explaining the development and implementation of the pedagogic model. The first version of the model, derived from the literature, was examined by experts and revised. After that, the new version, named the CSI Model, was implemented in an optics course of a Vietnamese university for a semester, and its effectiveness was investigated in the light of the three research questions.

This chapter will examine whether the research goal has been achieved using the following criteria: (1) increasing interaction within the learning environment, (2) improving students' physics test results, and (3) enhancing students' critical thinking skills.

7.1 Conclusion

7.1.1 Research Question One: In What Ways does the Application of the Pedagogic Model Increase Interaction within the Learning Environment?

Different sources of data were collected to investigate the influences of the CSI model on interactions within the learning environment: scores on the degree of interaction in the classes recorded by two observers, interviews with the lecturer and the teaching assistant, interviews with the students and students' questionnaires. The findings from the observers' scores show that the degree of interaction at the end of the semester was significantly higher than at the beginning of the semester. Comments from the students, the lecturer and the teaching assistant confirm this finding: the interaction between participants, both inside and outside the Optics classes, increased during the semester.

7.1.2 Research Question Two: Does the Application of the Pedagogic Model Improve Students' Physics Test Results?

Optics tests are the main data sources to support investigating this research question. In addition, interviews with the students, the lecturer and the teaching assistant help to provide more insight into how the application of CSI Model supports improvement in the students' optics test results.

The students' optics test results show that students' post-test scores are significantly higher than the students' pre-test scores. Furthermore, the Morning Group used more ICT in the light of the CSI Model than the Afternoon Group (the Morning Group utilised the online LMS to support their learning while the Afternoon Group did not) and the post-test scores of the Morning Group are significantly higher than those of the Afternoon Group. The effect size Cohen's d in this case is strong. It is noted that there is no significant difference between the two groups' optics pre-test scores.

The findings from interviews with the students, the lecturer and the teaching assistant show that the implementation of the CSI Model seems to enhance the students' learning. These findings are in line with the test results.

7.1.3 Research Question Three: In What Ways does the Application of the Pedagogic Model Enhance Students' Critical Thinking Skills?

The main instruments to examine if the students' critical thinking skills are enhanced are the California Critical Thinking Skill Tests (i.e. pre- and post-tests). The test results show that students' post-test scores are significantly higher than their pre-test scores. The students' responses to the questionnaire confirm this finding. Most of the students believe that their critical thinking skills have improved after studying the Optics Course. The findings from the tests and the students' questionnaires indicate that the students' thinking skills are enhanced.

In summary, to investigate the effectiveness of the CSI Model in the context of Vietnam, the data was collected by a range of methods (e.g. tests, questionnaires, interviews and observations) and from different groups of people (e.g. the students, the observers, the lecturer and the teaching assistant). The findings indicate that the CSI Model fulfils the prerequisite criteria: the application of this model can increase interaction within the learning environment, improve students' physics test results and enhance the students' critical thinking skills. These findings suggest that the implementation of the CSI model achieved the pedagogical goal of integrating appropriate learning principles with ICT to teach physics in the context of this Vietnamese university optics course.

The use of ICT in this study included distributed resources via the internet, software and technology tools supporting face-to-face lectures, a course management system – LMS and email system. MS PowerPoint, the LMS, laptop computers and LCD projectors were the software and technology tools used by the students and the lecturer to support students' learning. Email and other electronic media were also utilised by students for the purposes of discussing academic issues with their classmates and doing group work.

7.2 Implications

The successful implementation of the CSI Model in this study suggests some possible implications at different levels of education. At the teacher level, as mentioned in chapter one, the current essential need for Vietnamese teachers is to acquire new understanding and skills in using ICT to support their teaching. However, little literature guides these teachers. The CSI Model can inform teachers how to use ICT to support teaching.

For teacher training and professional development purposes, the current study can provide teachers with insight and understandings on how to use ICT to assist students' individual and social learning. On the social aspect of learning, ICT may be used as tools to promote interactions between students-teacher, students-students and students-learning resources.

Learning styles of Vietnamese students are strongly influenced by Confucian beliefs. It is argued that under this influence, a learning style which contains cooperation and interaction is not suitable for Vietnamese students (Pham, 2008). This study shows that it is possible to develop cooperative and interactive learning in the Vietnamese context.

At the level of Vietnam's Ministry of Education and Training (MOET), this study can provide possible guidance for the current strategy of implementing ICT into education. Although Vietnam's MOET educational reforms promote the use of ICT to support teaching with a student-centred approach, a teacher-centred approach still dominates Vietnamese classrooms. The current study shows how

ICT was used to enhance student-centred learning. Training Vietnamese teachers on implementing the CSI Model into their teaching practice is a possible means to help the MOET achieve the goal of the educational reforms.

At the level of world-wide research, there is little searchable research on the integration of ICT in teaching physics in Vietnam. The current study contributes to this literature with insights into the use of ICT in teaching Physics in the Vietnam context.

As a result of this study, I conclude that the use of ICT informed by the CSI Model can enhance interaction in the learning environment, students' physics performance and students' critical thinking skills. The model may provide useful guidance for teachers who need to integrate ICT into their teaching practice.

7.3 Limitations and Recommendations for Further Research

While the results of implementing the CSI Model have been very positive the study is limited in scale. The research was conducted in one course in a university and while the CSI Model may have worked well in this case, further work is needed to see if it is successful in other situations. The current research provides an overall picture of the effectiveness of the CSI Model, but has not investigated the detailed nature of the changes to students' learning and their critical thinking. Further studies could be conducted in this topic. Some recommended topics include:

- Implementing the CSI Model in different educational and cultural contexts

- Investigating in more details the nature of the changes in students' learning and critical thinking skills while implementing the CSI Model. Some suggested data collection methods are unstructured interviews with teachers before and after class, videos recording of classes and records of online learning interactions.

7.4 Concluding Remarks

The CSI Model is a pedagogic model integrating constructivist and sociocultural learning principles with ICT. Within the context of this study, this research reveals that this model is an effective pedagogic model that increases participant interactions, physics learning and critical thinking skills. Mr Van – the participant lecturer – concluded that the CSI Model "is a suitable pedagogic model for University A in particular and for Vietnam in general… It is very useful for teaching practice where ICT is implemented".

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Appendix 1 Expert-evaluation for the Pedagogic Theoretical Model of Integrating Constructivist Learning Principles and ICT

Expert-evaluation for the Pedagogic Theoretical Model of Integrating Constructivist Learning Principles and ICT

March 8th, 2011

University of Waikato

Centre for Science & Technology Education Research

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Criteria for Evaluating the Model

Expert's Name:

Contact information:

Objectives of Expert-evaluation:

- To determine to what extent the model is suitable for teaching Physics
- To get the feedback from experts and improve the model

Considerations:

1. Is the model able to reflect the nature of students' learning? Please give comment in this aspect.

2. What are the strong points of the model, as a pedagogic theoretical framework, supporting teaching Physics? What are the weaknesses?

3. Which parts of the model should be improved so that it will support for teaching Physics effectively? How should the model be revised?

About the Model

1. Background

Constructivism is a theory about cognition of human beings. Recent studies indicate that the implementation of information communication technology (ICT) in education based on constructivist principles benefits students significantly in learning Physics. This results in changing the learners' conceptualization of Physics (Driver & Scott, 1996), increasing students' performance in Physics (Christina & Dimitrios, 2008), improving collaboration between learners (Wang, 2009) and impacting positively on learners' critical thinking skills (Al-Fadhli & Khalfan, 2009). Constructivism is a useful philosophy for education, but does not offer a specific model for teaching and learning.

Many lecturers in the Physics Department in the School of Education at Can Tho University, Vietnam have used MS PowerPoint in teaching Physics; some of them have implemented the internet and other educational software. Nevertheless, it seems that there is not a pedagogic model which supports integrating ICT into the teaching of Physics.

This research aims to develop an effective pedagogic model which integrates ICT and constructivist principles into the teaching Physics in the context of the Physics Department. The focus of ICT in this study is the use of internet, software, multimedia resources, course management systems and computer-based testing systems in education.

2. Theoretical Framework for the Research

Based on current literature, a pedagogic theoretical framework has been created. The framework is built on two constructivist learning principles, one of which originates from cognitive constructivism; the other from social constructivism.

Knowledge, from the constructivist perspective, cannot be transferred from teachers to students but is constructed by students as individuals in a social environment. This environment contains books, reading materials, learning tasks, curricula, teachers, peers and learning supporting tools (e.g. computers, experimental equipment, films, software and online course management system) (von Glasersfeld, 2005). There are two important learning constructivist principles that are derived from constructivism and will be used as a guide for this research: (1) learning requires learners to create and to self-organise their knowledge, and (2) learning is a social process.

Appendix 1 Expert-evaluation for the pedagogic model

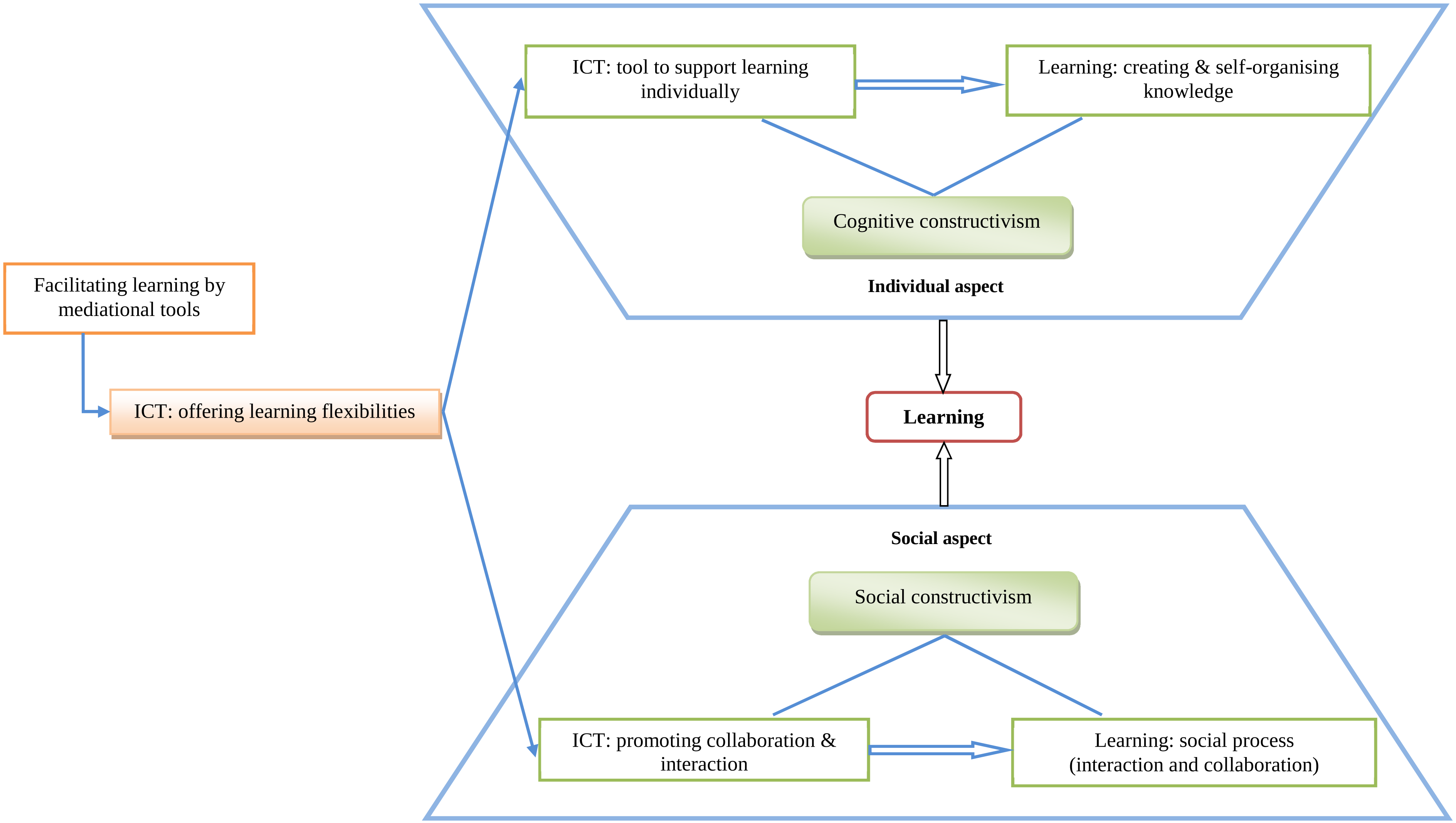


Figure 1 The Pedagogic Theoretical Model of Integrating Constructivist Learning Principles and ICT

Figure 1 presents the pedagogic theoretical model of integrating constructivist learning principles and ICT. In general, the nature of learning can be enlightened by cognitive and social constructivist points of view: learning means creating and self-organising knowledge (cognitive constructivism), and learning is a social process of interaction and making meaning (social constructivism). Moreover, leaning is facilitated by tools; ICT is one important tool which offers considerable learning flexibilities. By providing several options for students, ICT can be considered as an effective means to support internal learning processes (individual aspect of learning) and as a powerful tool to promote collaboration and interaction (social aspect of learning). The following section will explain the model in detail. Some parts of the framework in Figure 1 will be presented again in order to help readers locate the parts in the model easily.

Constructivist Learning Principles

Learning, which is in the centre of the diagram, consists of two aspects, individual and social. The nature of learning in personal aspect is explained by cognitive constructivism; and in social aspect by social constructivism.

The first constructivist principle is that learning is development which requires learners to create and to self-organise their knowledge (Fosnot & Perry, 2005)**.** The first principle concerns human internal process of constructing knowledge (cognitive constructivism) (Figure 2). Learning normally starts by observing or experiencing, continues with making meaning and relating

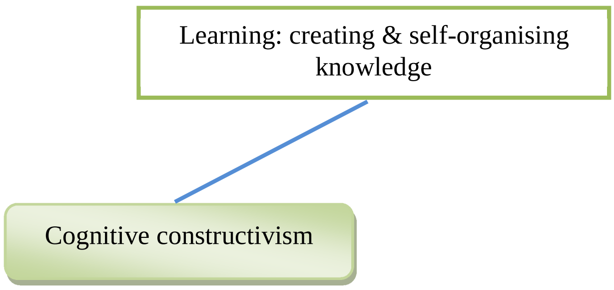


Figure 2 Constructivist Principle One

current experiences to cognitive systems which learners have developed. Learners then integrate or differentiate the new knowledge; the new balance in their cognitive system is formed. Based on this nature of learning, educators can facilitate students by offering them as many opportunities to observe and to experience as possible in a learning context. The teaching content should be based on learners' prior knowledge. Teachers need to provide the appropriate help so that learners can relate new cognition to prior cognitive systems, then make the change and enrich their understanding.

The second constructivist learning principle is that learning is a social process (Tobin & Tippins, 1993) (Figure 3). Individuals construct their understandings in social settings. While the first principle focuses on the personal cognition component of the learning process, the second principle is directed at the social component of learning (social constructivism). Social interaction between learner-learner and between learner-teacher plays an important role in the learning process. Students should be provided with a supportive, opened and interactive environment which helps them discover knowledge. This learning environment facilitates learners to generate as many of their own hypotheses, models and possibilities as possible, including both affirmative and contradictory possibilities. Moreover, the learning environment encourages students to present, discuss, negotiate their points of view with community, test their hypotheses, models or their possibilities, and find out the viability (viable knowledge).

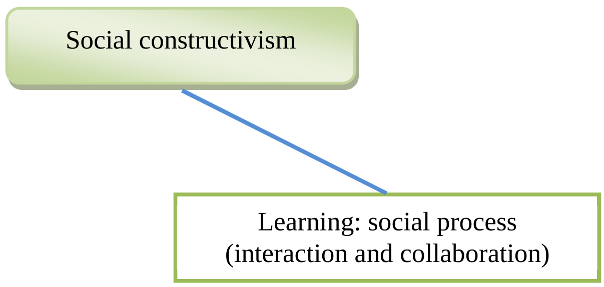


Figure 3 Constructivist Principle Two

Learning, from a cognitive constructivist point of view, is a process of creating a new balance of cognitive system and re-organising knowledge; and, from a social constructivist perspective, a social process of interaction and meaning making. Learning is the process involving both learners' social interaction and their personal thinking process; as a result, the two elements in the diagram have a mutual relationship, exist together and cannot be separated from each other.

ICT Facilitating Learning

Learning is facilitated by mediational tools, such as signs, diagrams, language, experimental equipment, technical tools and technology (Daniels, 2008) (Figure 4). The tools are powerful to enhance learning processes. They may direct thinking and may shape actions. The mediational tools will stimulate learners to construct their own knowledge in a social context if teachers use them effectively. For the purpose of the study, the tool "information communication technology" will be a focus.

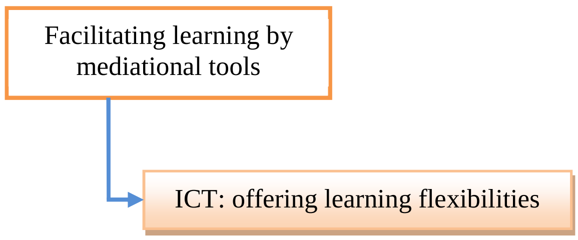


Figure 4 Mediational Tools

ICT Offers Flexible Learning Environments for Students

A flexible learning environment usually means distance learning in common ways of thinking, yet flexible learning relates to many different choices for students such as time, topics and learning materials. Places where learners contact teachers and other learners are just one dimension of flexibility.

Collis and Moonen (2001) state that flexibility in learning concerns a variety of options for learners in the learning environment. In the current research, ICT is used to diversify options for students in terms of learning resources, instructional organisation of learning and communication. In addition, ICT is applied to support learners’ choices on social organisations of learning and languages.

First, learners are provided with a wide range of learning resources, including traditional resources (e.g. textbook, library resources) and ICT resources (e.g. educational software, rich resources on internet and video resources). The flexibility in learning resources connects with three dimensions: topics, key learning materials and learning resources.

Second, the instructional organisation of learning becomes more flexible since face-to-face lectures, a course management system and a computer-based testing system are integrated. Software and technology tools are implemented in face-to-face lectures. The integration of face-to-face lectures, a course management system and a computer-based testing system provides learners with many alternatives for submitting assignments and interacting within a course. This integration permits them deciding on the pace of study, choosing instructional organisation of learning (e.g. face-to-face and online), time and place to contact teachers and other learners (e.g. in classes at fix time or off campus during weekdays). Moreover, the application of ICT gives students choices of methods and technology for obtaining support and making contact.

Third, the implementation of ICT offers different methods of communication such as face-to-face, e-mail, chat, forum and social networking websites. It enhances flexibility of social organisation of learning and time, location and methods of interacting.

Last, students explore various alternatives of social organisations of learning and languages. ICT actively promotes communication; therefore, it effectively fosters different kinds of social organisations of learning (e.g. working in groups, working individually and combination). Rich learning resources, including ICT, are also in different languages so students can choose languages which are appropriate for them.

By providing several options of learning resources, instructional organisation, communication, social organisation of learning and language, ICT seems to facilitate learning effectively. It can be a tool for individuals to create and self-organise knowledge and also a tool for learning via promoting collaboration and interaction.

ICT Is Used as a Tool to Support Learning Individually

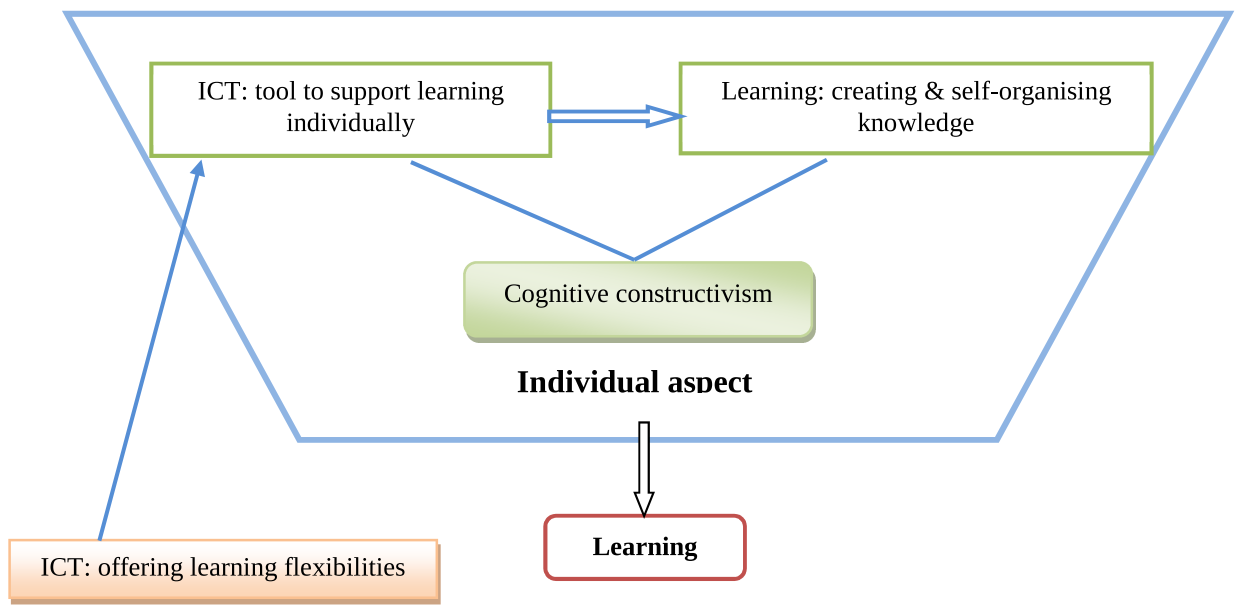


Figure 5 ICT Supporting Learning on Individual Aspect

ICT, from cognitive constructivist point of view, is a tool for learners to construct knowledge individually (see Figure 5). As discussed above, learning from a cognitive constructivist perspective is the process of self-organising knowledge. Learners experience, make assimilation and accommodation, and then gain new equilibrium of cognition. ICT is a means for internalising knowledge. For example, ICT offers rich learning material and resources including texts, photos, audio, video and software; hence, learners can observe new phenomena and experience in a supportive environment. Furthermore, software that is used to draw mind maps (e.g. MINDMAP, SmartDraw and FreeMind) can be an effective tool for students to organise ideas and refine their system of cognition.

ICT Promotes Collaboration and Interaction

ICT stimulates interaction by providing a supportive and encouraging communication environment (see Figure 6). That ICT offers different and convenient ways of interaction has been mentioned above. The interaction will be examined in two contents: interaction with teachers and interaction between learners.

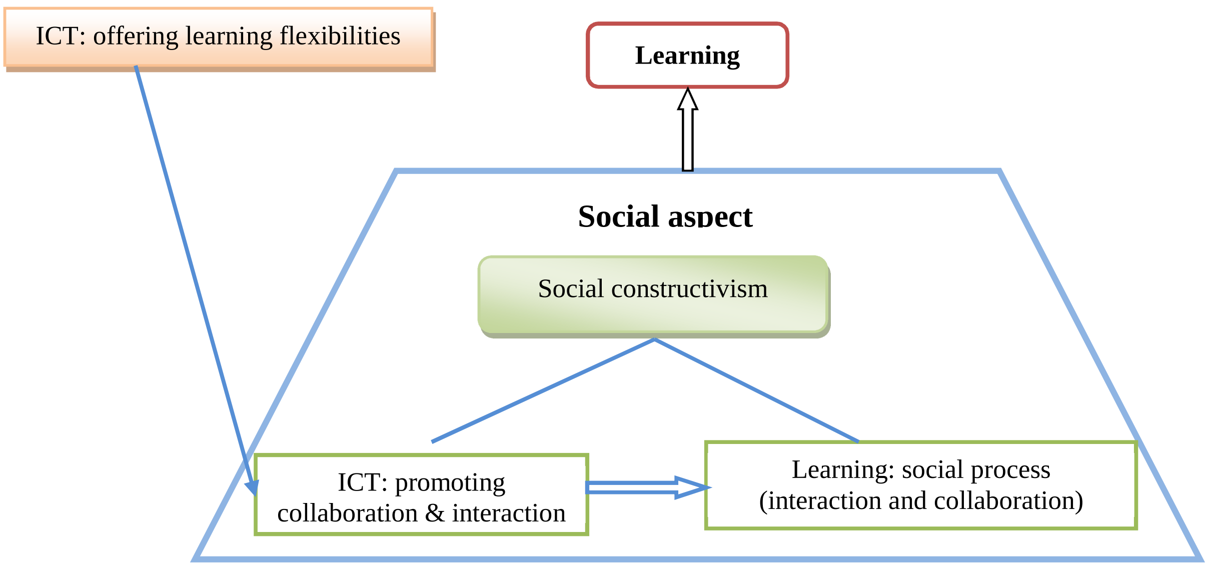


Figure 6 ICT Supporting Learning on Social Aspect

Interaction between the teacher and the learner plays a crucial role in learning processes. That teachers design curricula, content of knowledge, lesson plans, learning materials and learning activities creates a learning environment for students to interact with and to make meaning. ICT is a powerful tool for teachers to design the interactive learning environment, to facilitate learning by answering questions, mentoring, scaffolding, giving feedback and so on. Learners can interact and get support from educators through different ways, such as face-to-face, email, chat and forum.

The collaboration among learners is also enhanced. ICT provides flexibility in methods of communication. The more flexible communication is the greater collaboration can be fostered. The application of ICT may provide an interactive learning environment in which students explain and share ideas or hypotheses, justify them, argue or negotiate, and build knowledge.

In general, learning, including internal re-organising of knowledge and constructing understanding in a society, is assisted by mediational means (e.g. equipment of experiments and ICT). ICT that is considered as a type of mediational mean provides learning flexibilities on learning resources, instructional organisation of learning, communication, social organisation of learning and language. By offering the flexibilities, ICT promotes interaction and individuals' learning activities. That ICT is used as a tool to support individuals learning connects to cognitive constructivism, while ICT fostering interaction and collaboration relates to social constructivism.

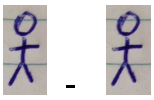
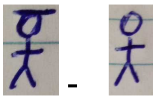
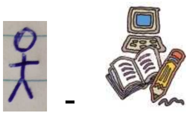
Note: references can be provided if required.

Appendix 2 The Observation Scheme

The Observation Scheme

Week ……...   Group ……..
For Recording Interaction within Learning Environment
Date: ………………….. Time: ……………… Location …………..
Period No.: …………..   Observer's name: …………………………………….

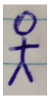
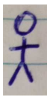
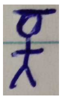
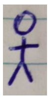
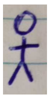
Observation 1: minute 10th-15th

Timeline / **Interaction between**	**1st 60s**	**2nd 60s**	**3rd 60s**	**4th 60s**	**5th 60s**	**6th 60s**	**Note**
 [student(s) – student (s)]							
 [teacher – student (s)]							
 [student(s) – learning material(s)]							
Task							
Task in hand							
Previous task							
Future task							
Non-task							

The degree of interaction: Scale of 10

	10	9	8	7	6	5	4	3	2	1	0	
Very highly interactive	_	_	_	_	_	_	_	_	_	_	_	Not interactive at all

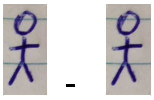
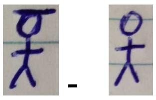
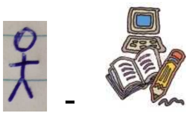
Observation 2: minute 20th-25th

Timeline / Interaction between	1st 60s	2nd 60s	3rd 60s	4th 60s	5th 60s	6th 60s	Note
 -  [student(s) – student (s)]							
 -  [teacher – student (s)]							
 -  [student(s) – learning material(s)]							
Task							
Task in hand							
Previous task							
Future task							
Non-task							

The degree of interaction: Scale of 10

	10	9	8	7	6	5	4	3	2	1	0	
Very highly interactive	_	_	_	_	_	_	_	_	_	_	_	Not interactive at all

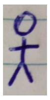
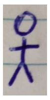
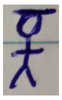
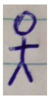
Observation 3: minute 30th-35th

Timeline / Interaction between	1st 60s	2nd 60s	3rd 60s	4th 60s	5th 60s	6th 60s	Note
 [student(s) – student (s)]							
 [teacher – student (s)]							
 [student(s) – learning material(s)]							
Task							
Task in hand							
Previous task							
Future task							
Non-task							

The degree of interaction: Scale of 10

	10	9	8	7	6	5	4	3	2	1	0	
Very highly interactive	_	_	_	_	_	_	_	_	_	_	_	Not interactive at all

Observation 4: minute 40th-45th

<table>
<tr><th>Timeline / Interaction between</th><th>1st 60s</th><th>2nd 60s</th><th>3rd 60s</th><th>4th 60s</th><th>5th 60s</th><th>6th 60s</th><th>Note</th></tr>
<tr><td> - 
[student(s) – student (s)]</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td> - 
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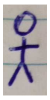
<tr><td> - 
[student(s) – learning material(s)]</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="8">Task</td></tr>
<tr><td>Task in hand</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Non-task</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

The degree of interaction: Scale of 10

	10	9	8	7	6	5	4	3	2	1	0	
Very highly interactive	_	_	_	_	_	_	_	_	_	_	_	Not interactive at all

Your Comments about the Period:

Appendix 3 The Questionnaires for Students' Evaluation

Student questionnaire

The questionnaire delivered at the beginning of the semester

A Background Information (Tick your answers in the boxes ☑)

1. Your gender ☐ Male ☐ Female

2. Your age ....

3.	When did you first enrol in this program?	2011 ☐	2010 ☐	2009 ☐	2008 ☐	Other ☐
4.	How long have you been using a computer?	Less than 6 months ☐	7 – 12 months ☐	13 – 18 months ☐		Other *(Please specify)* ☐ ....

5. Do you have a computer at home? ☐ Yes ☐ No

6. Do you have internet connection at home? ☐ Yes ☐ No

7. How often do you access internet?

☐ Everyday	☐ Once per two weeks
☐ 6 – 3 times a week	☐ Once a month
☐ Once to twice a week	☐ Other *(Please specify)* ....

8. How often do you use computer?

☐ Everyday	☐ Once per two weeks
☐ 6 – 3 times a week	☐ Once a month
☐ Once to twice a week	☐ Other *(Please specify)* ....

9. How often do you access chat-software, mail, forum discussion and social net work? **(Tick all that apply)**

	Everyday	**6 – 3 times a week**	**Once to twice a week**	**Once per two weeks**	**Once a month**	**Other** *(Please specify)*
CTU webmail	☐	☐	☐	☐	☐	☐..........
CTU forum	☐	☐	☐	☐	☐	☐..........
Flickr	☐	☐	☐	☐	☐	☐..........
Yahoo Mail	☐	☐	☐	☐	☐	☐..........
Yahoo Messenger (Chat)	☐	☐	☐	☐	☐	☐..........
Gmail	☐	☐	☐	☐	☐	☐..........
Google Talk (Chat)	☐	☐	☐	☐	☐	☐..........
Other (Please specify)	☐	☐	☐	☐	☐	☐..........
....						
....	☐	☐	☐	☐	☐	☐..........

B. How frequently did you do following activities when you attended the courses in the Semester I? Tick your answers in the boxes (☑).

In class activities

	In every lecture	Often	Sometimes	Rarely	Not at all
1. During lectures, how often did the instructor ask questions?	☐	☐	☐	☐	☐
2. During lectures, how often did the instructor answer questions?	☐	☐	☐	☐	☐
3. How often did you ask questions in class? *	☐	☐	☐	☐	☐
4. How often did you contribute to class discussions?*	☐	☐	☐	☐	☐
5. How often did you make a class presentation?*	☐	☐	☐	☐	☐
6. Worked with classmates on tasks/assignments/projects during class*	☐	☐	☐	☐	☐
7. How often did you come to class without completing readings or assignments?*	☐	☐	☐	☐	☐

Out of classroom

How often did you do following activities?	Once a week	Once per two weeks	Once a month	Once per semester	Not at all	Other
8. Worked on a paper or project that required integrating ideas or information from various sources*	☐	☐	☐	☐	☐	☐
9. Worked with classmates outside of class to prepare class assignments/projects/tasks*	☐	☐	☐	☐	☐	☐
10. Used an electronic medium (Internet, forum, e-mail, instant messaging, chat group, etc.) to discuss with classmates about academic issues *	☐	☐	☐	☐	☐	☐
11. Used electronic medium to communicate with an instructor	☐	☐	☐	☐	☐	☐
12. Used an electronic medium to support doing groups assignments/projects/tasks	☐	☐	☐	☐	☐	☐

*: adapted or revised from NSSE (National Survey of Student Engagement, 2010)

C. How do you expect us to organise teaching and learning activities of this course?

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Thank you very much for investing your time on answering the questionnaire!

The questionnaire delivered at the end of the semester

A Background Information (Tick your answers in the boxes ☑)

1. Your gender ☐ Male ☐ Female

2. Your age ....

3. When did you first enrol in this program?

2011	2010	2009	2008	Other
☐	☐	☐	☐	☐

4. How long have you been using a computer?

Less than 6 months	7 – 12 months	13 – 18 months	Other *(Please specify)*
☐	☐	☐	☐ ....

5. Do you have a computer at home? ☐ Yes ☐ No

6. Do you have internet connection at home? ☐ Yes ☐ No

7. How often do you access internet?

☐ Everyday ☐ Once per two weeks

☐ 6 – 3 times a week ☐ Once a month

☐ Once to twice a week ☐ Other *(Please specify)* ....

8. How often do you use computer?

☐ Everyday ☐ Once per two weeks

☐ 6 – 3 times a week ☐ Once a month

☐ Once to twice a week ☐ Other *(Please specify)* ....

9. How often do you access chat-software, mail, forum discussion and social net work? **(Tick all that apply)**

	Everyday	**6 – 3 times a week**	**Once to twice a week**	**Once per two weeks**	**Once a month**	**Other** *(Please specify)*
CTU webmail	☐	☐	☐	☐	☐	☐..........
CTU forum	☐	☐	☐	☐	☐	☐..........
Flickr	☐	☐	☐	☐	☐	☐..........
Yahoo Mail	☐	☐	☐	☐	☐	☐..........
Yahoo Messenger	☐	☐	☐	☐	☐	☐..........
(Chat)						
Gmail	☐	☐	☐	☐	☐	☐..........
Google Talk (Chat)	☐	☐	☐	☐	☐	☐..........
Other (Please specify)	☐	☐	☐	☐	☐	☐..........
....						
....	☐	☐	☐	☐	☐	☐..........

B. How frequently did you do following activities when you attended this Optics Course? Tick your answers in the boxes (☑).

In class activities

	In every lecture	Often	Sometimes	Rarely	Not at all
1. During lectures, how often did the instructor ask questions?	☐	☐	☐	☐	☐
2. During lectures, how often did the instructor answer questions?	☐	☐	☐	☐	☐
3. How often did you ask questions in class? *	☐	☐	☐	☐	☐
4. How often did you contribute to class discussions?*	☐	☐	☐	☐	☐
5. How often did you make a class presentation?*	☐	☐	☐	☐	☐
6. Worked with classmates on tasks/assignments/projects during class*	☐	☐	☐	☐	☐
7. How often did you come to class without completing readings or assignments?*	☐	☐	☐	☐	☐

Out of classroom

How often did you do following activities?	Once a week	Once per two weeks	Once a month	Once per semester	Not at all	Other
8. Worked on a paper or project that required integrating ideas or information from various sources*	☐	☐	☐	☐	☐	☐
9. Worked with classmates outside of class to prepare class assignments/projects/tasks*	☐	☐	☐	☐	☐	☐
10. Used an electronic medium (Internet, forum, e-mail, instant messaging, chat group, etc.) to discuss with classmates about academic issues *	☐	☐	☐	☐	☐	☐
11. Used electronic medium to communicate with an instructor	☐	☐	☐	☐	☐	☐
12. Used an electronic medium to support doing groups assignments/projects/tasks	☐	☐	☐	☐	☐	☐

*: adapted or revised from NSSE (National Survey of Student Engagement, 2010)

B. To what extent have your thinking skills improved after this Optics Course? Tick your answers in the boxes (☑).

	Exceedingly	Very much	Somewhat	A little bit	Not at all
1. Interpretation: *To comprehend and express meaning*	☐	☐	☐	☐	☐
2. Analysis: *To identify inferential relationships*	☐	☐	☐	☐	☐
3. Evaluation: *To assess credibility and logical strength*	☐	☐	☐	☐	☐
4. Inference: *To identify and secure elements needed to draw reasonable conclusions; To form hypotheses; To consider relevant information and to deduce the consequences flowing from data, statements, evidence...*	☐	☐	☐	☐	☐
5. Explanation: *To state results, to justify, to present one's reasoning*	☐	☐	☐	☐	☐
6. Inductive reasoning: *Reasoning from specific observations to broader generalizations and theories*	☐	☐	☐	☐	☐
7. Deductive reasoning *Reasoning from the more general to specific*	☐	☐	☐	☐	☐

Thank you very much for investing your time on answering the questionnaire!

Bản hỏi dành cho sinh viên – Đầu học kỳ

A. Thông tin chung (**Xin vui lòng chọn câu trả lời bằng cách đánh dấu vào ô vuông ☑)**

1. Giới tính ☐ Nam ☐ Nữ

2. Tuổi ....

3. Bạn nhập học vào ngành này năm nào?

2011	2010	2009	2008	Khác
☐	☐	☐	☐	☐

4. Bạn đã sử dụng máy tính bao lâu?

Dưới 6 tháng	7 – 12 tháng	13 – 18 tháng	Khác *(Xin ghi cụ thể)*
☐	☐	☐	☐ ....

5. Bạn có máy tính ở nhà không? ☐ Có ☐ Không

6. Bạn có nối mạng internet ở nhà không? ☐ có ☐ không

7. Bạn vào mạng internet có thường xuyên không?

Mỗi ngày	3-6 lần/ tuần	1-2 lần/tuần	1 lần/2 tuần	1 lần/tháng	Khác *(Xin ghi cụ thể)*
☐	☐	☐	☐	☐	☐ ....

8. Bạn sử dụng máy tính có thường xuyên không?

Mỗi ngày	3-6 lần/ tuần	1-2 lần/tuần	1 lần/2 tuần	1 lần/tháng	Khác *(Xin ghi cụ thể)*
☐	☐	☐	☐	☐	☐ ....

9. Bạn có thường sử dụng chat, e-mail, forum và và các mạng xã hội không? (**Xin đánh dấu vào tất cả các loại dưới đây mà bạn đã sử dụng**)

	Mỗi ngày	**3-6 lần/ tuần**	**1-2 lần/ tuần**	**1 lần/ 2 tuần**	**1 lần/ tháng**	**Khác** *(Xin ghi cụ thể)*
CTU webmail	☐	☐	☐	☐	☐	☐..........
CTU forum	☐	☐	☐	☐	☐	☐..........
Flickr	☐	☐	☐	☐	☐	☐..........
Yahoo Mail	☐	☐	☐	☐	☐	☐..........
Yahoo Messenger (Chat)	☐	☐	☐	☐	☐	☐..........
Gmail	☐	☐	☐	☐	☐	☐..........
Google Talk (Chat)	☐	☐	☐	☐	☐	☐..........
Khác *(Xin ghi cụ thể)*	☐	☐	☐	☐	☐	☐..........

B.Các hoạt động sau đây có diễn ra thường xuyên trong các học phần bạn đã học ở HK I không?

(Xin vui lòng chọn câu trả lời bằng cách đánh dấu vào ô vuông ☑)

Các hoạt động trên lớp

	Mỗi giờ học	Thường xuyên	Đôi khi	Hiếm khi	Không có
1. Trong các giờ học, thầy/cô có thường hỏi các câu hỏi không?	☐	☐	☐	☐	☐
2. Trong các giờ học, thầy/cô có thường trả lời các câu hỏi của sinh viên không?	☐	☐	☐	☐	☐
3. Bạn có thường hỏi các câu hỏi trong các giờ học không?	☐	☐	☐	☐	☐
4. Bạn có thường tham gia thảo luận trong lớp không?	☐	☐	☐	☐	☐
5. Bạn có thường trình bày hay báo cáo trong lớp không?	☐	☐	☐	☐	☐
6. Bạn có thường làm việc chung với bạn học để hoàn thành các câu hỏi thảo luận/bài tập/dự án trong giờ học không?	☐	☐	☐	☐	☐
7. Bạn có thường **không** hoàn thành bài tập, bài đọc trước khi vào lớp không?	☐	☐	☐	☐	☐

Các hoạt động ngoài lớp

Bạn có thường tham gia các hoạt động dưới đây không?	**1 lần/ tuần**	**1 lần/ 2 tuần**	**1 lần/ tháng**	**1 lần/ học kỳ**	**Không có**	**Khác**
8. Làm một bài tập, dự án hoặc viết bài đỏi hỏi phải kết hợp nhiều ý tưởng hay thông tin từ nhiều nguồn khác nhau	☐	☐	☐	☐	☐	☐
9. Làm việc cùng với bạn để hoàn thành bài tập/dự án/câu hỏi thảo luận	☐	☐	☐	☐	☐	☐
10. Dùng công nghệ thông tin (internet, forum, e-mail, chat, chat group...) để thảo luận về các vấn đề học thuật với bạn	☐	☐	☐	☐	☐	☐
11. Dùng công nghệ thông tin để giao tiếp với thầy/cô giáo	☐	☐	☐	☐	☐	☐
12. Dùng công nghệ thông tin phục vụ cho làm bài tập nhóm, dự án và các câu hỏi thảo luận	☐	☐	☐	☐	☐	☐

C. Bạn mong muốn thầy/cô giảng dạy học phần này theo cách nào?

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Xin chân thành cảm ơn bạn đã dành thời gian trả lời bản hỏi!

Bản hỏi dành cho sinh viên – Cuối học kỳ

A. Thông tin chung (Xin vui lòng chọn câu trả lời bằng cách đánh dấu vào ô vuông ☑)

1. Giới tính ☐ Nam ☐ Nữ

2. Tuổi ....

3. Bạn nhập học vào ngành này năm nào?

2011	2010	2009	2008	Khác
☐	☐	☐	☐	☐

4. Bạn đã sử dụng máy tính bao lâu?

Dưới 6 tháng	7 – 12 tháng	13 – 18 tháng	Khác *(Xin ghi cụ thể)*
☐	☐	☐	☐ ....

5. Bạn có máy tính ở nhà không? ☐ Có ☐ Không

6. Bạn có nối mạng internet ở nhà không? ☐ có ☐ không

7. Bạn vào mạng internet có thường xuyên không?

Mỗi ngày	3-6 lần/ tuần	1-2 lần/tuần	1 lần/2 tuần	1 lần/tháng	Khác *(Xin ghi cụ thể)*
☐	☐	☐	☐	☐	☐ ....

8. Bạn sử dụng máy tính có thường xuyên không?

Mỗi ngày	3-6 lần/ tuần	1-2 lần/tuần	1 lần/2 tuần	1 lần/tháng	Khác *(Xin ghi cụ thể)*
☐	☐	☐	☐	☐	☐ ....

9. Bạn có thường sử dụng chat, e-mail, forum và và các mạng xã hội không? (**Xin đánh dấu vào tất cả các loại dưới đây mà bạn đã sử dụng**)

	Mỗi ngày	**3-6 lần/ tuần**	**1-2 lần/ tuần**	**1 lần/ 2 tuần**	**1 lần/ tháng**	**Khác** *(Xin ghi cụ thể)*
CTU webmail	☐	☐	☐	☐	☐	☐..........
CTU forum	☐	☐	☐	☐	☐	☐..........
Flickr	☐	☐	☐	☐	☐	☐..........
Yahoo Mail	☐	☐	☐	☐	☐	☐..........
Yahoo Messenger (Chat)	☐	☐	☐	☐	☐	☐..........
Gmail	☐	☐	☐	☐	☐	☐..........
Google Talk (Chat)	☐	☐	☐	☐	☐	☐..........
Khác *(Xin ghi cụ thể)*	☐	☐	☐	☐	☐	☐..........

B. Các hoạt động sau đây có diễn ra thường xuyên trong các học phần Quang Học không?

(Xin vui lòng chọn câu trả lời bằng cách đánh dấu vào ô vuông ☑)

Các hoạt động trên lớp

	Mỗi giờ học	**Thường xuyên**	**Đôi khi**	**Hiếm khi**	**Không có**
1. Trong các giờ học, thầy/cô có thường hỏi các câu hỏi không?	☐	☐	☐	☐	☐
2. Trong các giờ học, thầy/cô có thường trả lời các câu hỏi của sinh viên không?	☐	☐	☐	☐	☐
3. Bạn có thường hỏi các câu hỏi trong các giờ học không?	☐	☐	☐	☐	☐
4. Bạn có thường tham gia thảo luận trong lớp không?	☐	☐	☐	☐	☐
5. Bạn có thường trình bày hay báo cáo trong lớp không?	☐	☐	☐	☐	☐
6. Bạn có thường làm việc chung với bạn học để hoàn thành các câu hỏi thảo luận/bài tập/dự án trong giờ học không?	☐	☐	☐	☐	☐
7. Bạn có thường **không** hoàn thành bài tập, bài đọc trước khi vào lớp không?	☐	☐	☐	☐	☐

Các hoạt động ngoài lớp

Bạn có thường tham gia các hoạt động dưới đây không?	**1 lần/ tuần**	**1 lần/ 2 tuần**	**1 lần/ tháng**	**1 lần/ học kỳ**	**Không có**	**Khác** *(Xin ghi cụ thể)*
8. Làm một bài tập, dự án hoặc viết bài đỏi hỏi phải kết hợp nhiều ý tưởng hay thông tin từ nhiều nguồn khác nhau	☐	☐	☐	☐	☐	☐ ....
9. Làm việc cùng với bạn để hoàn thành bài tập/dự án/câu hỏi thảo luận	☐	☐	☐	☐	☐	☐ ....
10. Dùng công nghệ thông tin (internet, forum, e-mail, chat, chat group...) để thảo luận về các vấn đề học thuật với bạn	☐	☐	☐	☐	☐	☐ ....
11. Dùng công nghệ thông tin để giao tiếp với thầy/cô giáo	☐	☐	☐	☐	☐	☐ ....
12. Dùng công nghệ thông tin phục vụ cho làm bài tập nhóm, dự án và các câu hỏi thảo luận	☐	☐	☐	☐	☐	☐ ....

C. Theo bạn, các kĩ năng tư duy của bạn đã được phát triển như thế nào sau học phần này?

(Xin vui lòng chọn câu trả lời bằng cách đánh dấu vào ô vuông ☑)

	Tăng vượt bậc	Khá nhiều	Một ít	Rất ít	Không tăng
1. Diễn giải (Interpretation): *Hiểu và diễn đạt ý nghĩa*	☐	☐	☐	☐	☐
2. Phân tích (Analysis): *Xác định các mối quan hệ suy luận*	☐	☐	☐	☐	☐
3. Đánh giá (Evaluation): *Đánh giá độ tin cậy và mức độ logic*	☐	☐	☐	☐	☐
4. Suy luận (Inference): *Đưa ra kết luận hợp lý; Thiết lập các giả thuyết; Suy ra các hệ quả*	☐	☐	☐	☐	☐
5. Giải thích (Explanation): *Khẳng định kết quả, chứng minh, trình bày các lập luận*	☐	☐	☐	☐	☐
6. Suy luận qui nạp (Inductive reasoning): *Suy luận từ các quan sát chi tiết đến điều tổng quát hoặc các lý thuyết*	☐	☐	☐	☐	☐
7. Suy luận diễn dịch (Deductive reasoning): *Suy luận từ tổng quát đến chi tiết*	☐	☐	☐	☐	☐

Xin chân thành cảm ơn bạn đã dành thời gian trả lời bản hỏi!

Appendix 4 Vietnamese version of ‘a Booklet of the Theoretical Framework’

Tài liệu về mô hình sư phạm

Kết hợp nguyên lí học kiến tạo & văn hóa xã hội, và công nghệ thông tin trong dạy học Vật lý

The Integration of Constructivist & Sociocultural Learning Principles and ICT in Teaching Physics

University of Waikato

Centre for Science & Technology Education Research

Nguyễn Hồng Nhung

E-mail: hnn3@students.waikato.ac.nz

Tháng 12, 2011

1. Mở đầu

Lí thuyết kiến tạo (constructivism) là một lí thuyết về nhận thức của con người. Những nghiên cứu gần đây cho thấy việc sử dụng công nghệ thông tin (CNTT) trong dạy học, dựa trên các nguyên lí học kiến tạo mang lại cho sinh viên nhiều lợi ích trong việc học Vật lí. Nó hỗ trợ sinh viên trong việc học các khái niệm, định luật, định lí trong Vật lí (Driver & Scott, 1996), tăng kết quả học tập môn Vật lí (Christina & Dimitrios, 2008), tăng cường sự hợp tác của người học (Wang, 2009) và tác động tích cực đến tư duy bình luận của người học (critical thinking skills) (Al-Fadhli & Khalfan, 2009). Lí thuyết kiến tạo là một triết lí giáo dục hữu ích nhưng không phải là một mô hình hoặc một chiến lược dạy học cụ thể.

Trong những năm gần đây, nhiều giảng viên của Bộ môn Vật lí, Khoa Sư phạm, Trường Đại học Cần Thơ, Việt Nam sử dụng MS PowerPoint, internet và các phần mềm vào dạy học Vật lí. Tuy nhiên, dường như chưa có một mô hình lí thuyết rõ ràng để hỗ trợ cho việc sử dụng CNTT vào dạy học Vật lí.

Nghiên cứu này nhằm phát triển một mô hình lí thuyết cho việc sử dụng CNTT kết hợp với các nguyên lí học kiến tạo & văn hóa xã hội vào giảng dạy Vật lí. CNTT được đề cập trong nghiên cứu này là internet, phần mền, các nguồn tài nguyên học thuật đa phương tiện, hệ thống hỗ trợ dạy và học trên mạng (course management systems) và hệ thống hỗ trợ kiểm tra, thi cử trên máy tính (computer-based testing systems)

Mô hình được thiết kế dựa trên các tài liệu và các kết quả của những nghiên cứu gần đây. Nó được xây dựng dựa trên nguyên lí học kiến tạo & văn hóa xã hội. Mô hình lý thuyết này được xem như là một sổ tay hỗ trợ cho giảng viên về ứng dụng

CNTT vào dạy học Vật lí. Trước khi trình bày về mô mình, chúng tôi xin được nhấn mạnh lại vai trò quan trọng của giảng viên trong dạy học.

Giảng viên

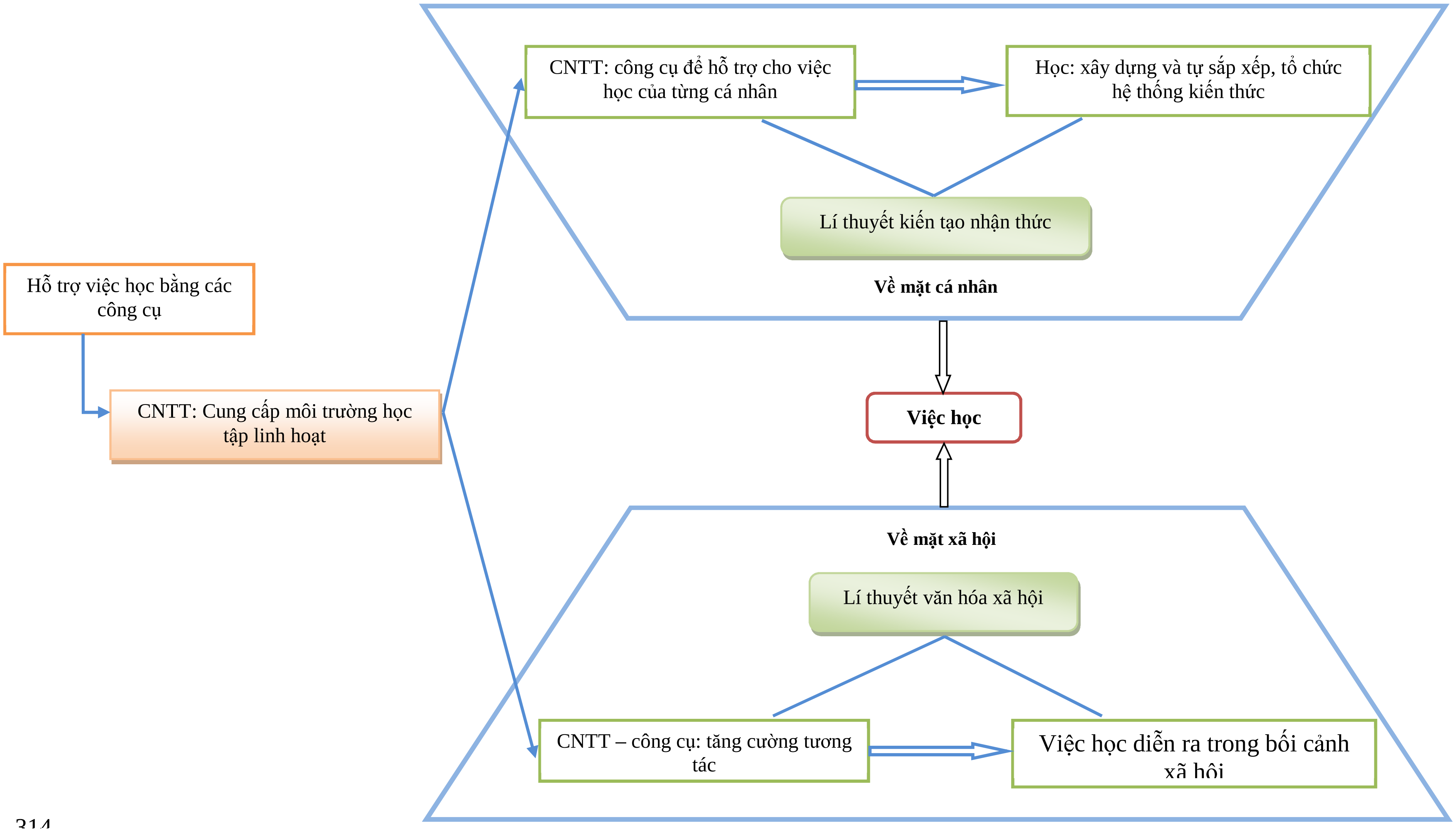
Giảng viên giữ vai trò chủ đạo trong quá trình dạy học: thiết kế chương trình học, các hoạt động học tập; quyết định nội dung giảng dạy; tổ chức các hoạt động học tập và hướng dẫn, định hướng sinh viên. Sự hỗ trợ và khuyến khích của giảng viên không chỉ quan trọng cho việc học của sinh viên mà còn là động cơ thúc đẩy sinh viên tìm kiếm tri thức.

Mô hình sau chủ yếu mô tả về vai trò của CNTT cho việc học, nhưng không có nghĩa là mô hình xem nhẹ vai trò của người thầy. Vai trò của người thầy là hết sức quan trọng; CNTT hay bất kỳ một mô hình sư phạm nào cũng không thể thay thế được. Người thầy mới là người sử dụng CNTT và mô hình sư phạm; hiệu quả của việc học, của mô hình sư phạm phụ thuộc mạnh mẽ vào người thầy.

2. Mô hình lí thuyết kết hợp các nguyên lí học kiến tạo, văn hóa xã hội và CNTT vào dạy học

Theo quan điển của lí thuyết kiến tạo và văn hóa xã hội, kiến thức không thể chuyển tải trực tiếp từ người dạy sang người học; kiến thức được xây dựng bởi người học như những cá nhân trong môi trường xã hội. Môi trường đó gồm có sách, học liệu, chương trình, các nhiệm vụ học tập, bạn bè và các công cụ hỗ trợ học tập. Đặc biệt là trong môi trường đó có sự hỗ trợ và hướng dẫn của người thầy.

Hình 1 mô tả mô hình lí thuyết kết hợp nguyên lí học kiến tạo, văn hóa xã hội và CNTT vào dạy học. Nhìn chung, việc học có thể được làm sáng tỏ từ những quan điểm của lí thuyết kiến tạo nhận thức và văn hóa xã hội: (1) Học là xây dựng kiến thức và tự sắp xếp, tổ chức hệ thống kiến thức, (2) Việc học diễn ra trong bối cảnh xã hội. Mặc khác, việc học cần có các công cụ hỗ trợ, trong đó CNTT là một công cụ quan trọng, giúp tạo môi trường học tập linh động cho sinh viên. Về phương diện từng cá nhân sinh viên, CNTT cung cấp cho sinh viên nhiều lựa chọn. Do đó, CNTT có thể được xem là một phương tiện hiệu quả để phục vụ cho quá trình học của mỗi sinh viên. Về phương diện xã hội của việc học, CNTT được xem là một công cụ tốt để tăng cường tương tác. Mô hình sẽ được mô tả chi tiết hơn trong phần sau đây. Để giúp người đọc dễ liên hệ giữa mô hình và phần đang mô tả, chúng tôi sẽ trình bày lại một số phần của hình 1.

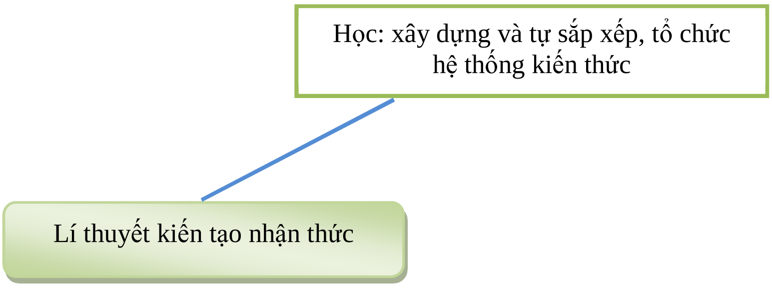


Hình 1 Mô hình lí thuyết kết hợp các nguyên lí học kiến tạo, văn hóa xã hội và CNTT vào dạy học

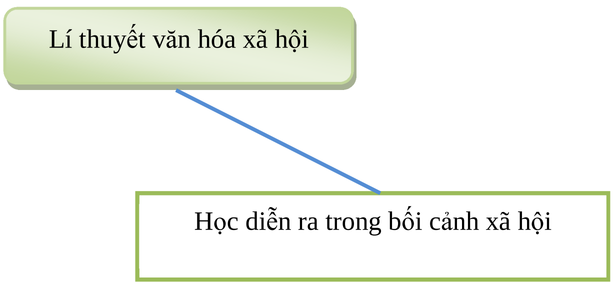
Nguyên lí học kiến tạo và văn hóa xã hội

Việc học (được đặt ở trung tâm của mô hình) bao gồm hai khía cạnh: cá nhân và xã hội. Bản chất việc học, về phương diện cá nhân, được giải thích bằng lí thuyết kiến tạo nhận thức; và về phương diện xã hội, đươc giải thích bằng lí thuyết văn hóa xã hội.

Nguyên lí thứ nhất: *Học là sự phát triển đòi hỏi người học phải xây dựng và tự sắp xếp, tổ chức hệ thống kiến thức của họ (Fosnot & Perry, 2005).* Nguyên lí này tập trung vào quá trình xây dựng kiến thức diễn ra trong suy nghĩ của từng cá nhân (lí thuyết kiến tạo nhận thức). Việc học thường bắt đầu bằng việc quan sát hay trải nghiệm, được tiếp diễn bằng việc hiểu và liên hệ kiến thức mới với hệ thống kiến thức sẵn có. Sau đó, người học kết hợp hoặc tìm những điểm khác biệt giữa kiến thức cũ và mới; hệ thống kiến thức được mở rộng hơn. Hiểu được bản chất này của việc học, người dạy nên tạo nhiều cơ hội để người học quan sát và trải nghiệm trong môi trường học tập. Nội dung giảng dạy cần được thiết kế dựa trên kiến thức vốn có của người học. Giảng viên nên hỗ trợ sinh viên một cách hợp lí để họ gắn kết kiến thức mới với kiến thức cũ, giúp thay đổi hệ thống kiến thức theo hướng tích cực và làm giàu thêm vốn hiểu biết của họ.



Hình 2 Nguyên lí học kiến tạo thứ nhất



Hình 3 Nguyên lí học kiến tạo thứ hai

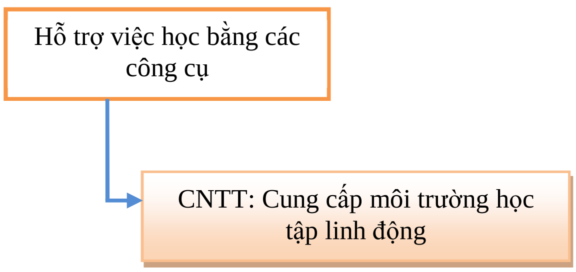
Nguyên lí thứ hai: *Việc học diễn ra trong bối cảnh xã hội* (Tobin & Tippins, 1993). Các cá nhân xây dựng kiến thức của họ trong môi trường xã hội. Trong khi nguyên lí thứ nhất tập trung vào thành tố cá nhân của quá trình học, nguyên lí thứ hai chú trọng vào thành tố xã hội của quá trình học (lí thuyết văn hóa xã hội). Tương tác xã hội giữa người dạy - người học, người học – người học, người học – học liệu đóng vai trò quan trọng trong quá trình học. Tiêu điểm của quan điểm văn hóa xã hỏi trong mô hình sư phạm này là việc học diễn ra trong bối cảnh xã hội và văn hóa; tri thức được phân phối trong xã hội, cả bên trong lẫn bên ngoài các cá nhân. Bằng cách khai thác các công cụ (ví dụ: ký hiệu, sơ đồ, ngôn ngữ, dụng cụ thí nghiệm, công cụ công nghệ và CNTT), người học tương tác với môi trường xã hội và cùng xây dựng kiến thức.

Theo quan điểm này thì sinh viên cần một môi trường học tập cởi mở, giàu tương tác và đầy khuyến khích để họ khám phá kiến thức. Môi trường học tập này tạo điều kiện thuận lợi để sinh viên đưa ra nhiều phương án, giả thuyết hoặc mô hình để giải quyết vấn đề. Các phương án, giả thuyết và mô hình này có thể là bỗ trợ nhau hoặc trái ngược nhau. Sinh viên cần được khuyến khích trình bày, thảo luận về quan điểm của họ, hoặc thử mô hình hay giả định của họ và xây dựng được kiến thức hữu ích cho bản thân.

Việc học theo quan điểm của lí thuyết kiến tạo nhận thức là một quá trình thiết lập các điểm cân bằng mới trong hệ thống kiến thức và sắp xếp lại kiến thức. Theo quan điểm của lí thuyết văn hóa xã hội, học là một quá trình tương tác xã hội để tìm sự hiểu biết. Quá trình học gắn liền với cả quá trình tương tác xã hội và quá trình tư duy của cá nhân. Vì vậy, hai thành tố này của quá trình học quan hệ tương hỗ, tồn tại cùng nhau và không thể tách rời nhau.

CNTT tạo điều kiện thuận lợi cho việc học

Các công cụ như kí hiệu, sơ đồ, ngôn ngữ, dụng cụ thí nghiệm, máy móc hay công nghệ tạo điều kiện cho việc học diễn ra thuận lợi hơn (Daniels, 2008). Các công cụ này giúp định hướng tư duy và hành động. Nếu sử dụng



Hình 4 Các công cụ hỗ trợ

các công cụ hiệu quả, người dạy sẽ kích thích người học xây dựng kiến thức một cách hiệu quả. Vì mục tiêu của nghiên cứu này, công cụ "CNTT" sẽ được trình bày một cách chi tiết.

CNTT cung cấp môi trường học tập linh động cho sinh viên

Theo cách nghĩ thông thường, môi trường học tập linh động (flexible learning environment) thường được hiểu là học từ xa. Tuy nhiên, Collis and Moonen (2001) cho rằng môi trường học tập linh động liên quan đến nhiều lựa chọn khác nhau mà người học được cung cấp như thời gian học, nội dung học, nguồn học liệu... Không gian học, nơi người học gặp giảng viên và các sinh viên khác (vd: lớp học, học từ xa) chỉ là một lựa chọn trong các lựa chọn mà môi trường học tập linh động cung cấp cho người học. Trong nghiên cứu này, CNTT được sử dụng để làm đa dạng hóa các lựa chọn cho sinh viên. Các lựa chọn này bao gồm nguồn học liệu, hình thức tổ chức dạy học, ngôn ngữ (Tiếng Anh & Tiếng Việt) và phương tiện để giao tiếp trong quá trình học tập.

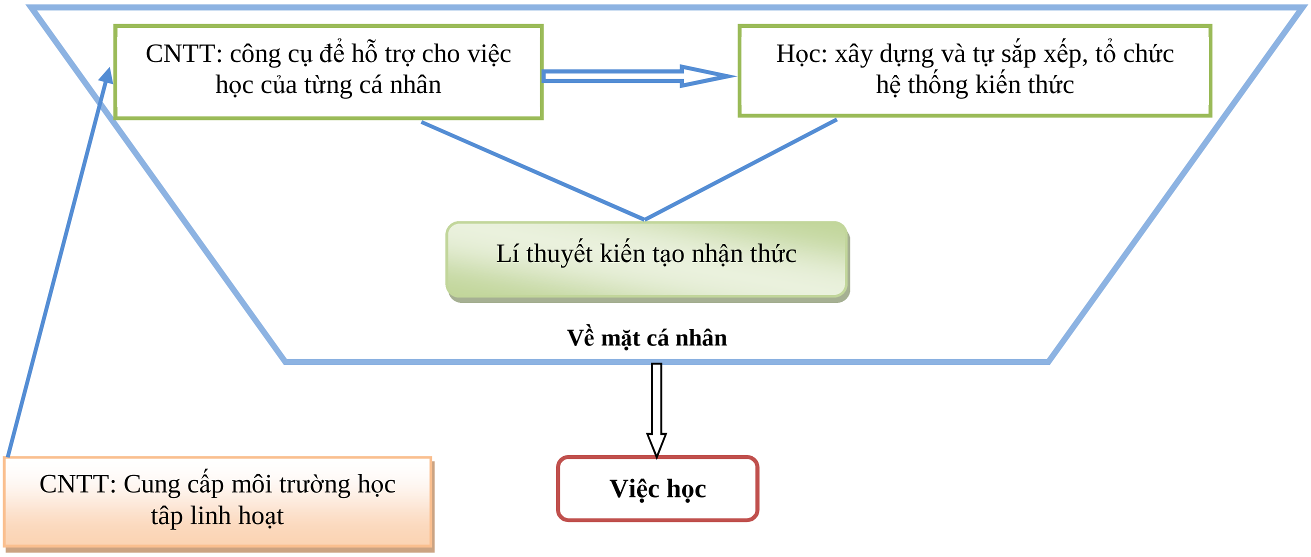
Người học được cung cấp nguồn học liệu phong phú. Ngoài tài liệu học tập truyền thống như giáo trình, bài giảng, sách ... , người học còn sử dụng nguồn học liệu điện tử, bao gồm các phần mền, nguồn học liệu đa phương tiện và internet.

Hình thức tổ chức dạy học cũng linh động hơn nhờ vào sự kết hợp giữa các giờ giảng trên lớp, hệ thống hỗ trợ dạy và học qua mạng và hệ thống hỗ trợ kiểm tra, thi cử trên máy tính. Các phần mền và các công nghệ khác cũng được sử dụng trong các giờ dạy trên lớp. Sự kết hợp này cho phép người học có nhiều lựa chọn trong học tập: thời gian trao đổi và thảo luận với thầy cô và bạn học; cách thức nộp bài tập; không gian và hình thức tổ chức dạy học (trên lớp & qua mạng); cách thức liên lạc và nhận được sự hỗ trợ trong quá trình học...

CNTT cho phép người học giao tiếp với thầy cô và bạn học bằng nhiều hình thức: gặp trực tiếp, dùng e-mail, chat, forum hay các trang Web mạng xã hội (social networking websites). CNTT làm tăng cường tính linh động của việc tổ chức dạy và học, thời gian, địa điểm và phương pháp giao tiếp và tương tác. Nhờ vậy, người học có thể học theo nhóm, tự học, kết hợp giữa tự học và học nhóm. Nguồn học liệu phong phú bằng tiếng anh và tiếng việt cho phép người học lựa chọn học liệu và ngôn ngữ phù hợp và cần thiết cho họ.

Bằng cách cung cấp nhiều lựa chọn cho người học như nguồn học liệu, hình thức tổ chức dạy và học, ngôn ngữ..., CNTT tạo điều kiện cho việc học diễn ra thuận lợi và hiệu quả hơn. CNTT có thể là một công cụ để cho cá nhân sinh viên xây dựng và tự sắp xếp kiến thức. Nó cũng là một công cụ hiệu quả để thức đẩy sự hợp tác và tương tác trong quá trình học.

CNTT được sử dụng như một công cụ để hỗ trợ cho cá nhân người học xây dựng kiến thức



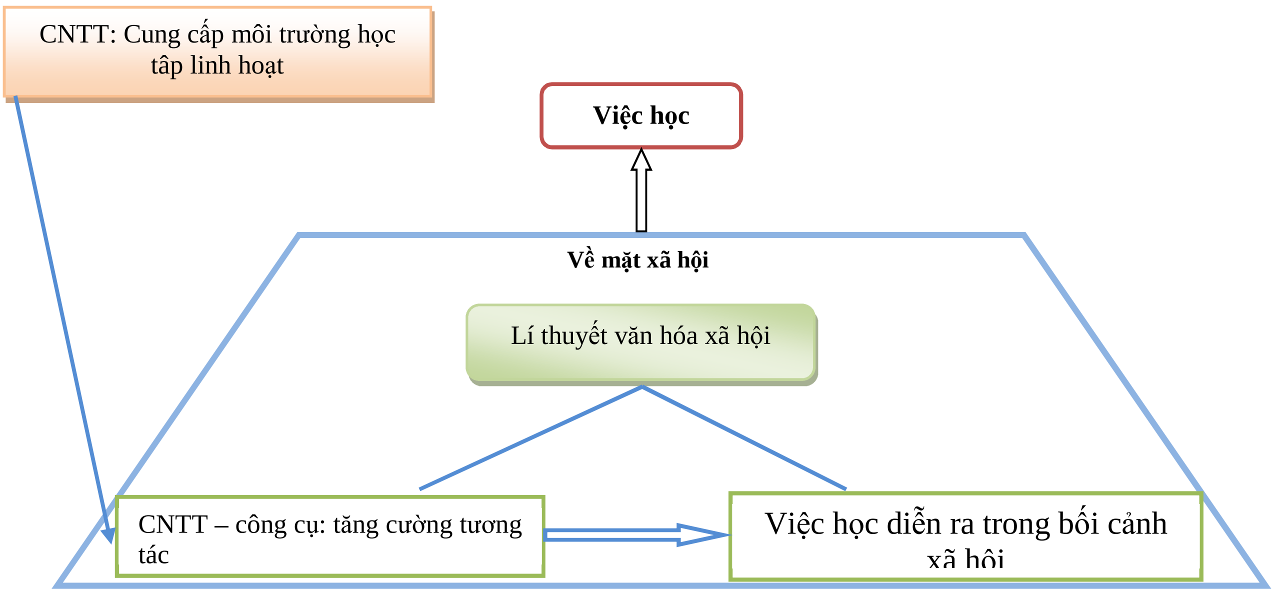
Hình 5 CNTT hỗ trợ việc học, về phương diện cá nhân

CNTT là một công cụ để cá nhân người học xây dựng kiến thức. Như đã được đề cập ở phần trên, việc học theo quan điểm của lí thuyết kiên tạo nhận thức là một quá trình tự sắp xếp, tổ chức lại kiến thức. Người học trãi nghiệm, làm quen, thay đổi, làm phong phú hệ thống kiến thức vốn có và đạt đến điểm cân bằng mới của hệ thống kiến thức. CNTT là một phương tiện giúp người học tiếp thu kiến thức. Chẳng hạn, nguồn học liệu điện tử phong phú như hình ảnh, từ ngữ, âm thanh, phim hay phần mềm giúp người học quan sát hiện tượng, quan sát thí nghiệm và thử nghiệm trong môi trường học tập; các phần mền để vẽ bản đồ tư duy như MINDMAP, SmartDraw hay FreeMind là công cụ hiệu quả giúp người học sắp xếp, tổ chức ý tưởng và hệ thống kiến thức của họ.

CNTT thúc đẩy tương tác

CNTT kích thích sự tương tác bằng cách tạo môi trường giao tiếp thuận lợi và khuyến khích. Tương tác ở đây bao gồm (1) tương tác giữa người dạy và người học, (2) tương tác giữa người học với người học và (3) tương tác giữa người học với học liệu và các nhiệm vụ học tập/ bài tập.

Tương tác giữa người dạy và người học giữ vai trò quan trọng trong quá trình dạy học. Người dạy thiết kế chương trình, nội dung, bài giảng, học liệu và các học động học. Bằng cách này, người dạy tạo trường học tập phù hợp cho người học; người học tương tác với môi trường học tập đó và xây dựng kiến thức. CNTT là một công cụ hữu ích để giảng viên thiết kế môi trường học tập tương tác. CNTT giúp giảng viên hỗ trợ sinh viên, trả lời câu hỏi, nhận xét và hướng dẫn sinh viên dưới nhiều thức: gặp trực tiếp, e-mail, chat, forum...



Hình 6 CNTT hỗ trợ việc học, về phương diện xã hội

Sự tương tác giữa những người học cũng được đẩy mạnh. CNTT giúp việc giao tiếp được linh hoạt hơn. Các hình thức giao tiếp càng linh hoạt, sự hợp tác càng được nuôi dưỡng và phát triển. CNTT tạo môi trường học tập tương tác, giúp người học có thể trình bày và trao đổi ý tưởng. Người học có thể nhận xét nhau, tranh luận, trao đổi và cùng nhau xây dựng kiến thức.

Nhờ CNTT, tương tác giữa người học với học liệu và các nhiệm vụ học tập/ bài tập trở lên phong phú hơn. Internet có nguồn học liệu đa dạng và phong phú. Với máy tính và internet, sinh viên có nhiều cơ hội để truy cập và sử dụng các học liệu này để làm bài tập, nghiên cứu và tìm hiểu tri thức. Giảng viên có thể thiết kế các bài tập/ nhiệm vụ học tập hiệu quả hơn, giúp sinh viên hoàn thành các bài tập này và nhận xét bài tập cho sinh viên. Hơn nữa, sinh viên có thể sử dụng CNTT như một công cụ hỗ trợ đắc lực cho việc làm bài tập và nghiên cứu.

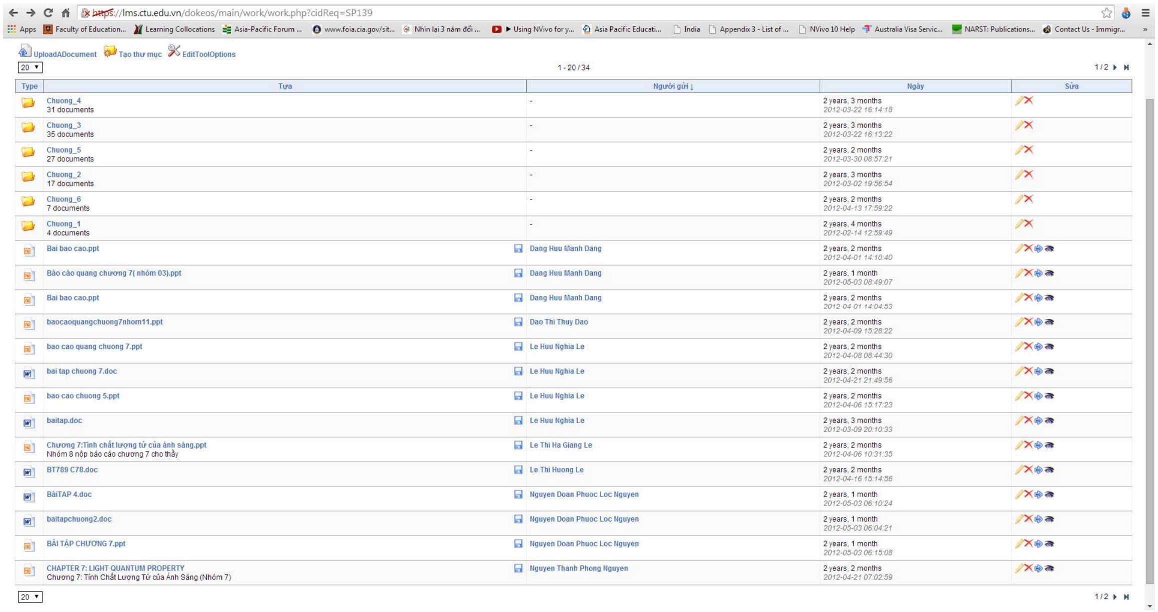
Tri thức phân phốn trong môi trường xã hội, cả bên trong lẫn bên ngoài con người. CNTT được xem như một công cụ giúp người học tương tác với người khác cũng như các nguồn học liệu và cùng nhau xây dựng tri thức và kỹ năng.

Nhìn chung, việc học bao gồm quá trình bên trong, tự xây dựng kiến thức của người học trong môi trường xã hội. Quá trình học được hỗ trợ bởi các công cụ, và CNTT là công cụ quan trọng. Nó giúp cung cấp môi trường học tập linh động về mặt học liệu, hình thức tổ chức dạy học, hình thức giao tiếp và ngôn ngữ. CNTT thông tin thúc đẩy sự tương tác giữa người dạy và người học, giữa người học với người học, giữa người học với học liệu và các nhiệm vụ học tập/ bài tập; cũng như thúc đẩy hoạt động học của từng các nhân.

Appendix 5 The Learning Management System

Students submitting and sharing their presentations

General



https://lms.ctu.edu.vn/dokeos/main/work/work.php?cidReq=SP139

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1 - 20 / 34 1 / 2

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Chuong_3 35 documents	-	2 years, 3 months 2012-03-22 16:13:22
Chuong_5 27 documents	-	2 years, 2 months 2012-03-30 08:57:21
Chuong_2 17 documents	-	2 years, 3 months 2012-03-02 19:56:54
Chuong_6 7 documents	-	2 years, 2 months 2012-04-13 17:59:22
Chuong_1 4 documents	-	2 years, 4 months 2012-02-14 12:59:49
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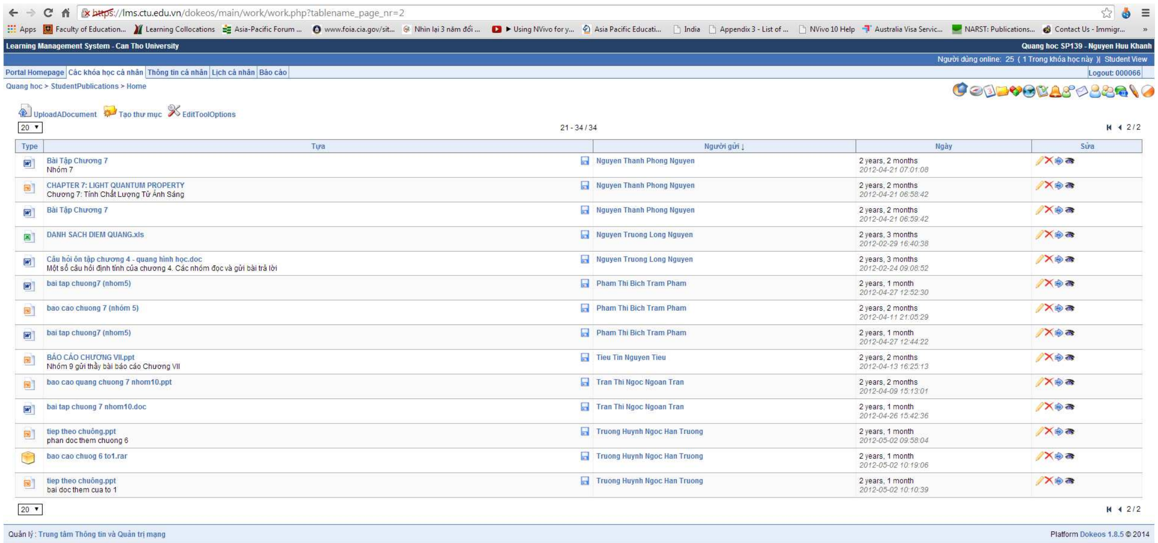
baitapchuong2.doc	Nguyen Doan Phuoc Loc Nguyen	2 years, 1 month 2012-05-03 06:04:21
BÀI TẬP CHƯƠNG 7.ppt	Nguyen Doan Phuoc Loc Nguyen	2 years, 1 month 2012-05-03 06:15:08
CHAPTER 7: LIGHT QUANTUM PROPERTY Chương 7: Tính Chất Lượng Tử của Ánh Sáng (Nhóm 7)	Nguyen Thanh Phong Nguyen	2 years, 2 months 2012-04-21 07:02:59



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Learning Management System - Can Tho University — Quang hoc SP139 - Nguyen Huu Khanh

Người dùng online: 25 (1 Trong khóa học này)| Student View

Portal Homepage | Các khóa học cá nhân | Thông tin cá nhân | Lịch cá nhân | Báo cáo — Logout: 000066

Quang hoc > StudentPublications > Home

UploadADocument Tạo thư mục EditToolOptions

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DANH SACH DIEM QUANG.xls	Nguyen Truong Long Nguyen	2 years, 3 months 2012-02-29 16:40:38
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bai tap chuong 7 nhom10.doc	Tran Thi Ngoc Ngoan Tran	2 years, 1 month 2012-04-26 15:42:36
tiep theo chuông.ppt phan doc them chuong 6	Truong Huynh Ngoc Han Truong	2 years, 1 month 2012-05-02 09:58:04
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tiep theo chuông.ppt bai doc them cua to 1	Truong Huynh Ngoc Han Truong	2 years, 1 month 2012-05-02 10:10:39

Quản lý : Trung tâm Thông tin và Quản trị mạng — Platform Dokeos 1.8.5 © 2014

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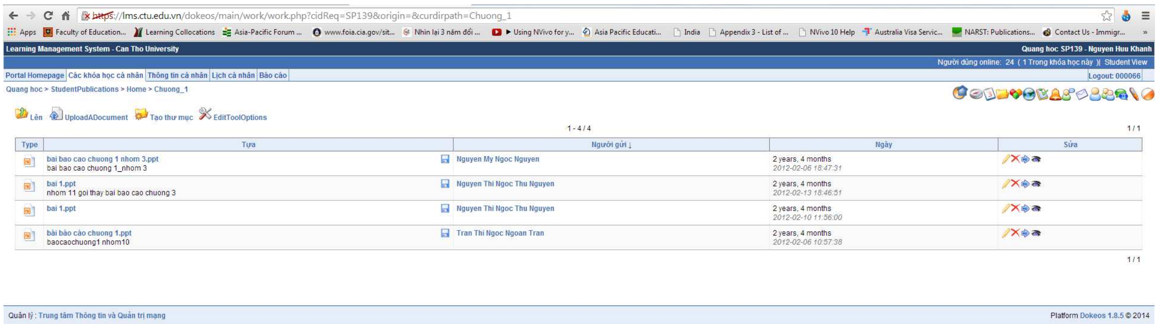

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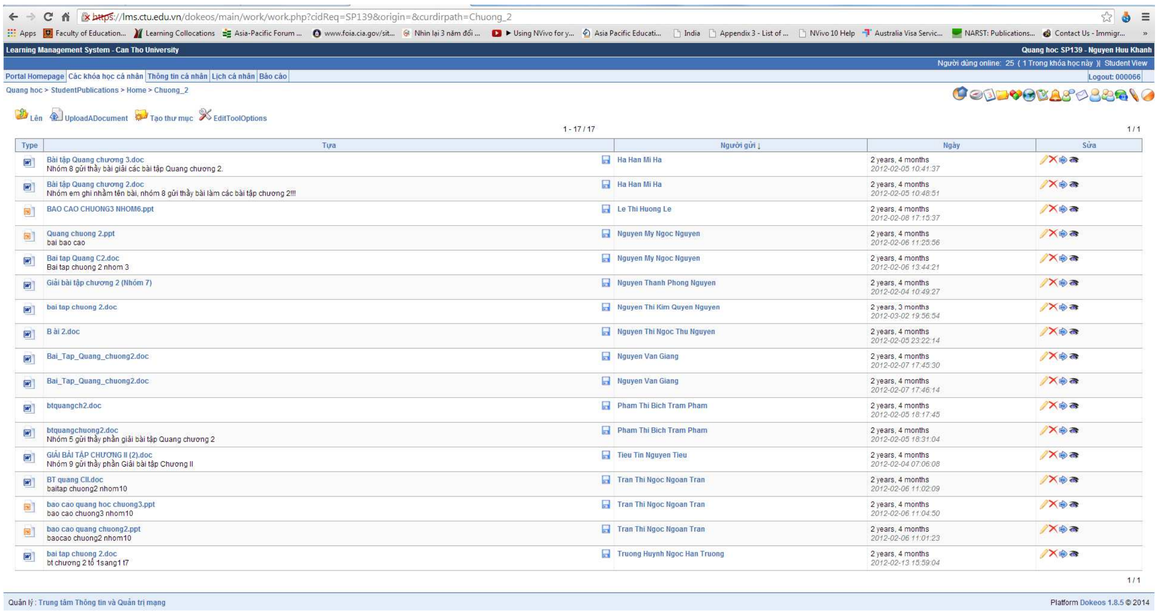

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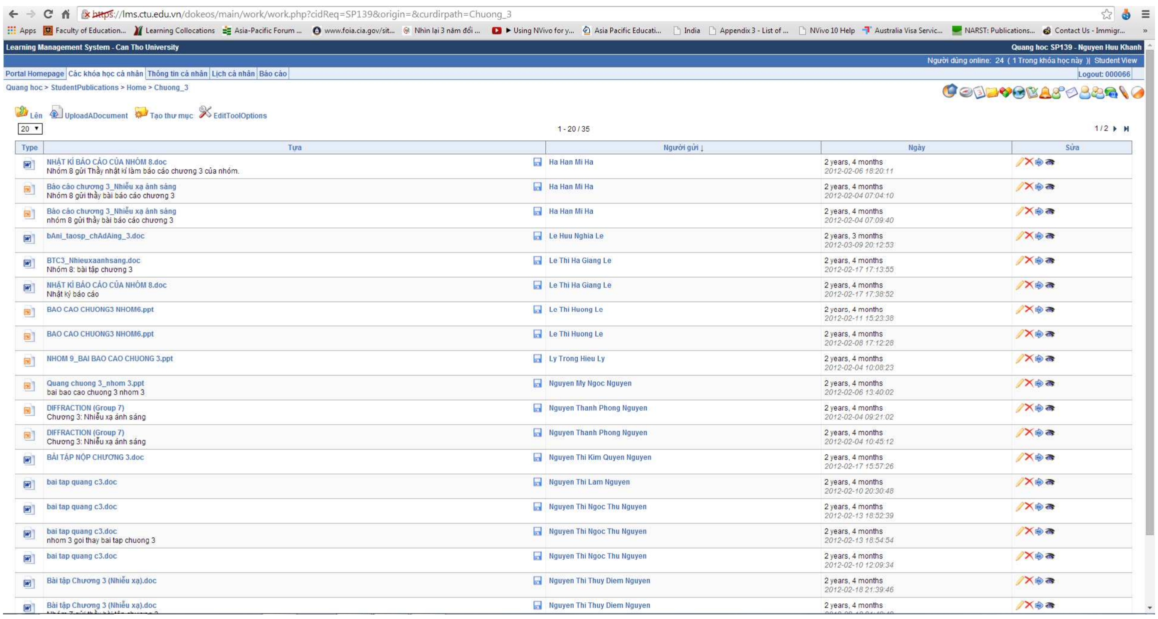

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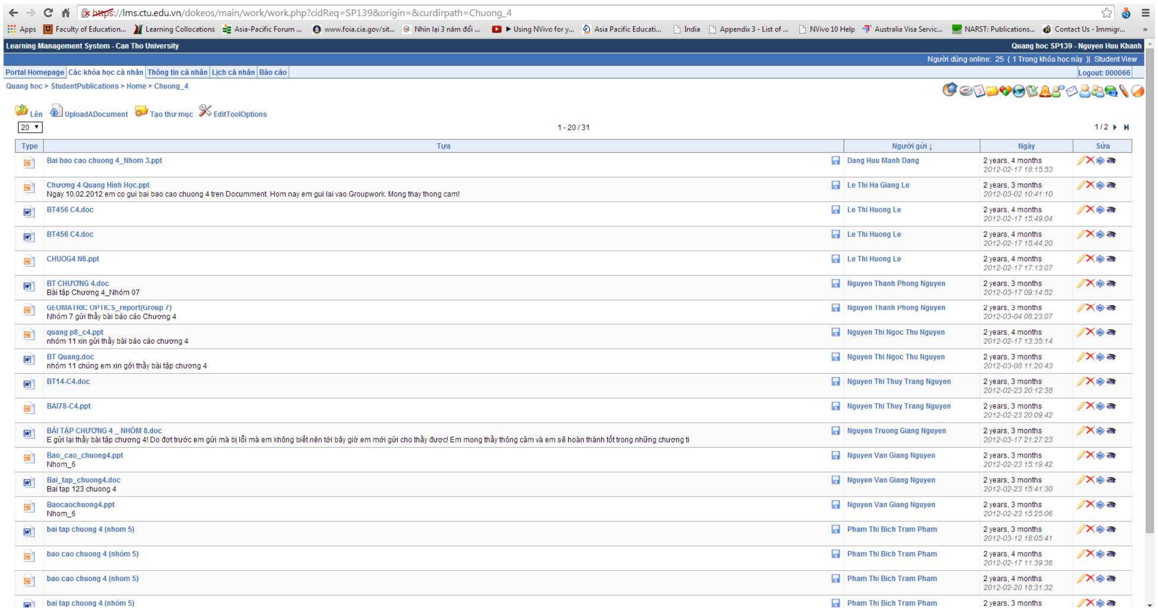

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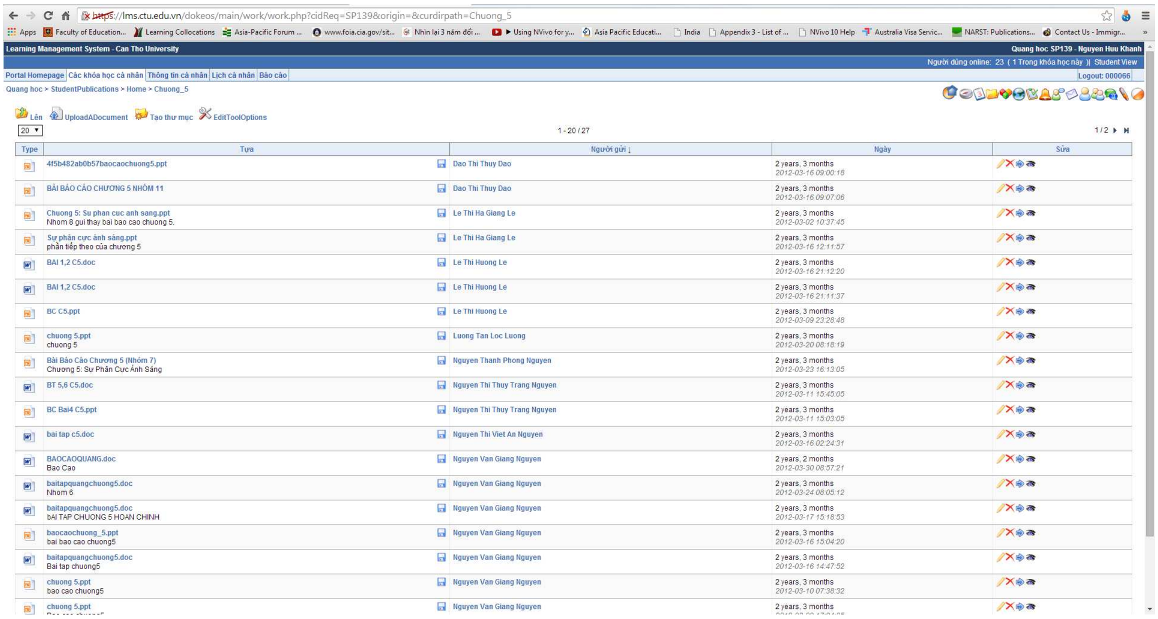

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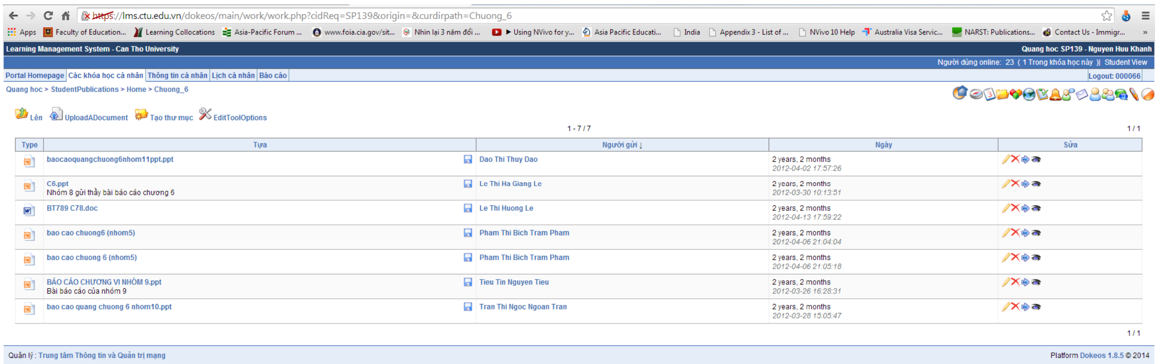

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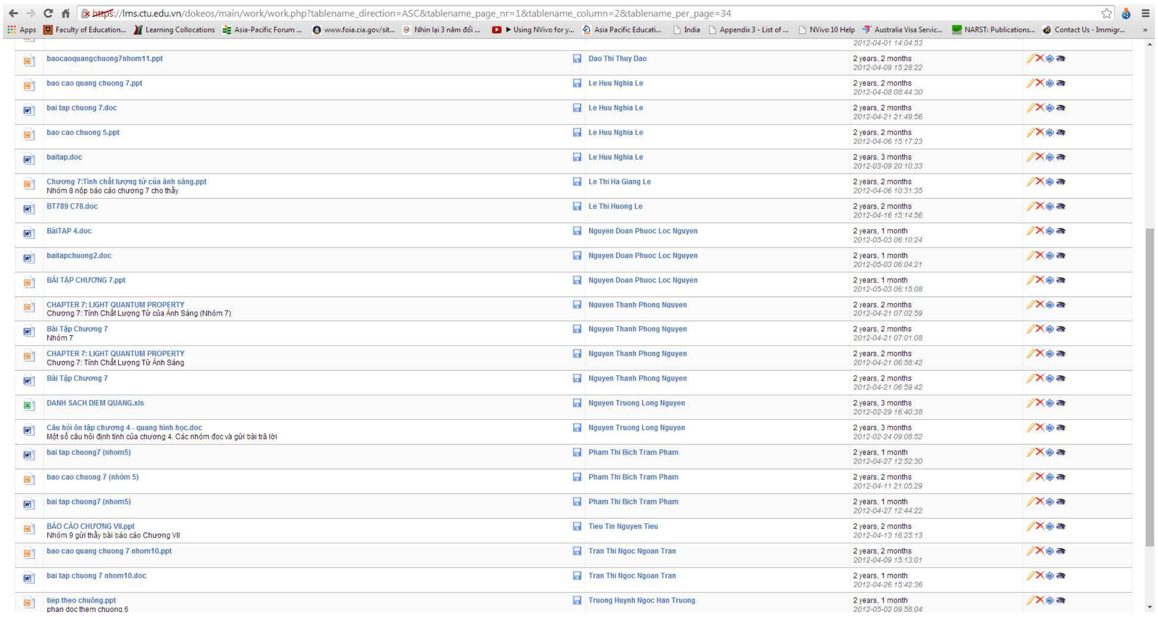
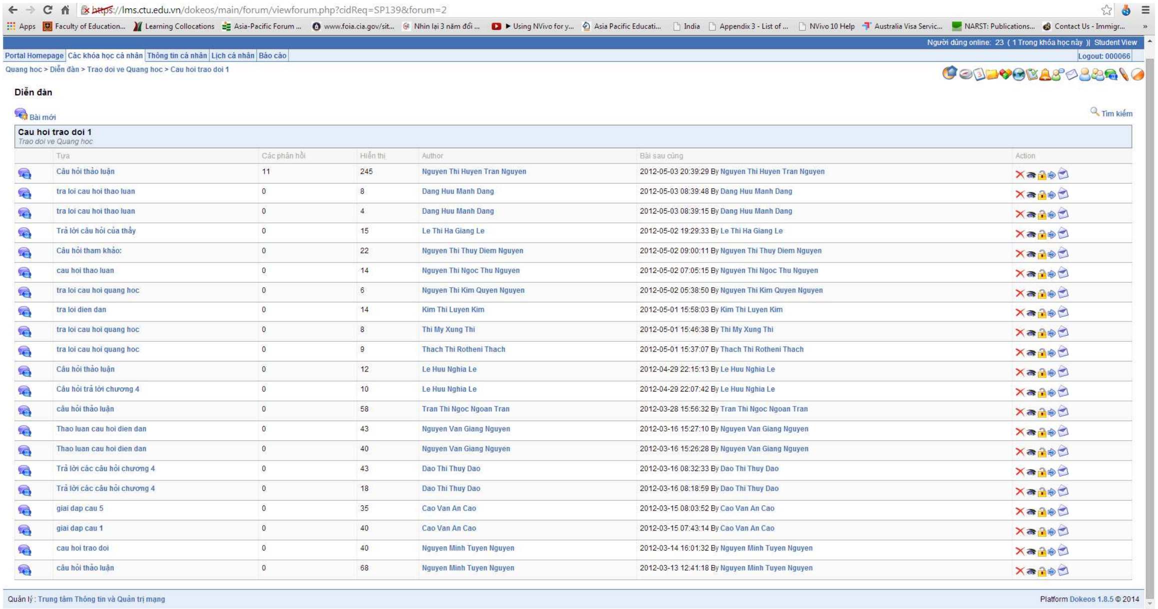
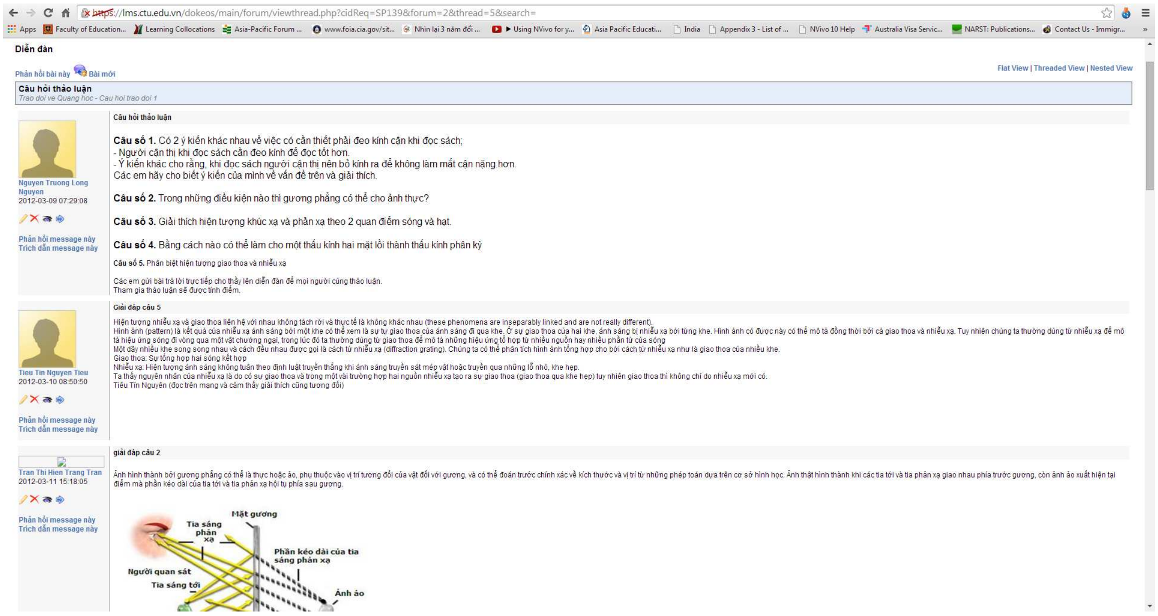
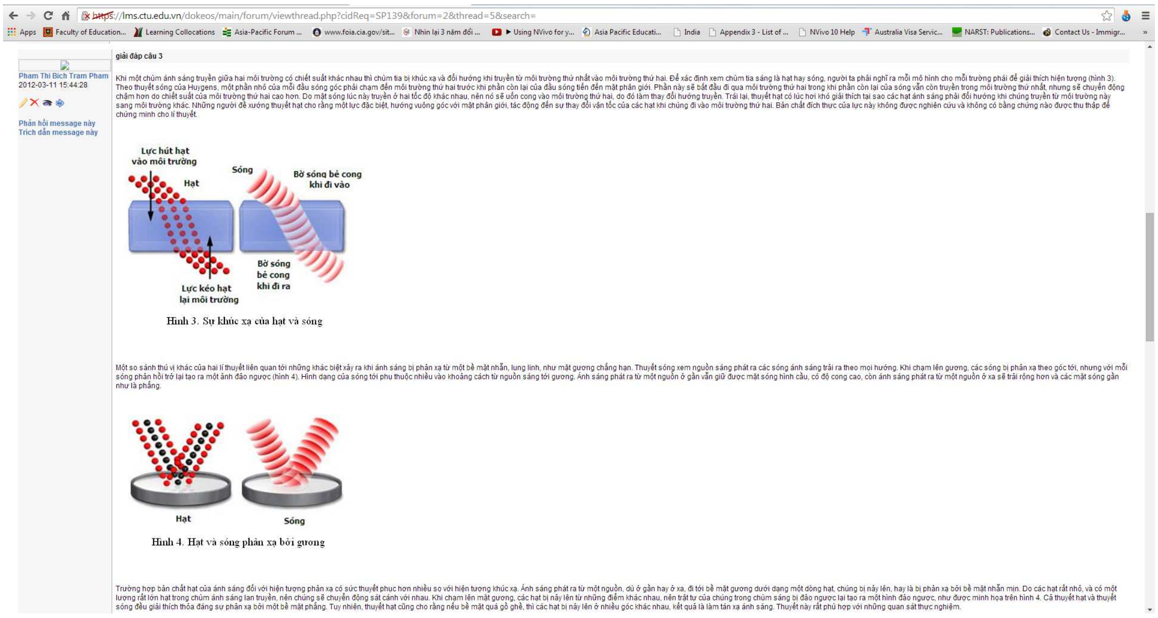


Students' forum discussion







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câu hỏi trao đổi	0	5	Nguyen Minh Tuyen Nguyen	2012-05-04 21:55:14 By Nguyen Minh Tuyen Nguyen
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thảo luận câu 3	0	5	Phan Thi Thuy Hong Phan	2012-05-02 18:39:32 By Phan Thi Thuy Hong Phan
trả lời câu hỏi diễn đàn	0	3	Bui Thu Thao Bui	2012-05-02 18:16:35 By Bui Thu Thao Bui
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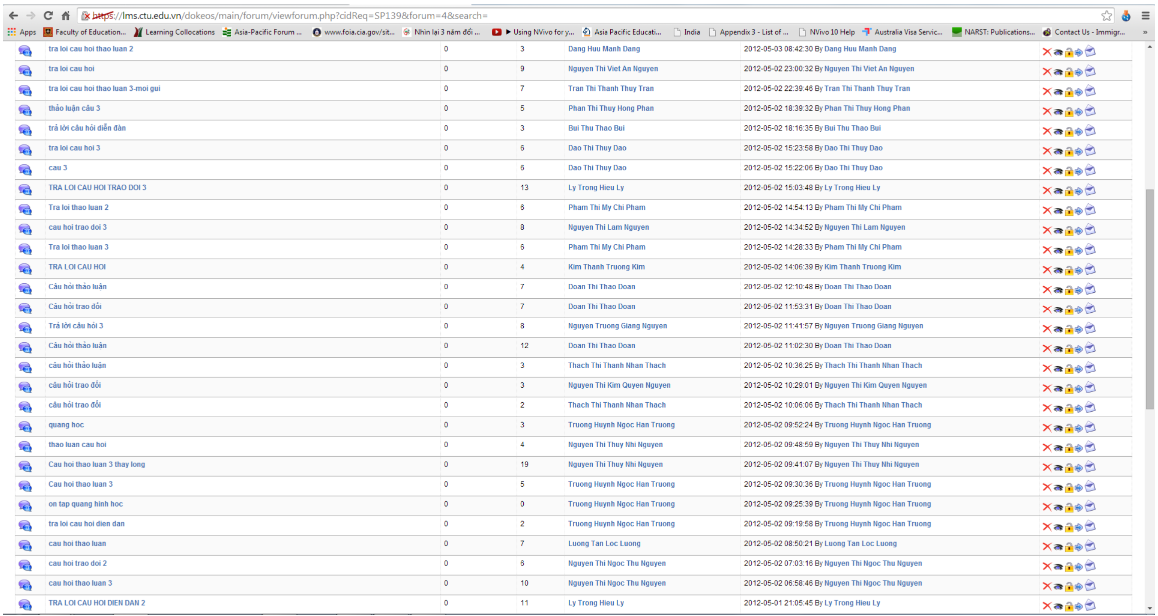

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trả lời câu hỏi diễn đàn	0	3	Bui Thu Thao Bui	2012-05-02 18:16:35 By Bui Thu Thao Bui
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TRA LOI CAU HOI TRAO DOI 3	0	13	Ly Trong Hieu Ly	2012-05-02 15:03:48 By Ly Trong Hieu Ly
Tra loi thao luan 2	0	6	Pham Thi My Chi Pham	2012-05-02 14:54:13 By Pham Thi My Chi Pham
cau hoi trao doi 3	0	8	Nguyen Thi Lam Nguyen	2012-05-02 14:34:52 By Nguyen Thi Lam Nguyen
Tra loi thao luan 3	0	6	Pham Thi My Chi Pham	2012-05-02 14:28:33 By Pham Thi My Chi Pham
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cau hoi thao luan	0	7	Luong Tan Loc Luong	2012-05-02 08:50:21 By Luong Tan Loc Luong
cau hoi trao doi 2	0	6	Nguyen Thi Ngoc Thu Nguyen	2012-05-02 07:03:16 By Nguyen Thi Ngoc Thu Nguyen
cau hoi thao luan 3	0	10	Nguyen Thi Ngoc Thu Nguyen	2012-05-02 06:58:46 By Nguyen Thi Ngoc Thu Nguyen
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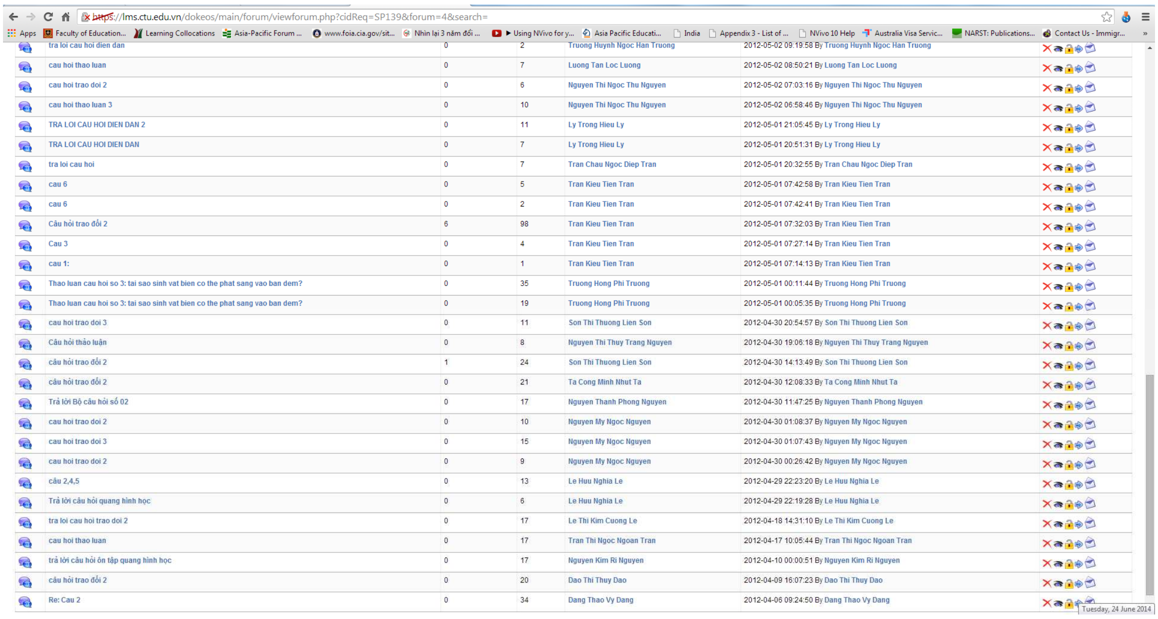

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cau hoi trao doi 2	0	6	Nguyen Thi Ngoc Thu Nguyen	2012-05-02 07:03:16 By Nguyen Thi Ngoc Thu Nguyen
cau hoi thao luan 3	0	10	Nguyen Thi Ngoc Thu Nguyen	2012-05-02 06:58:46 By Nguyen Thi Ngoc Thu Nguyen
TRA LOI CAU HOI DIEN DAN 2	0	11	Ly Trong Hieu Ly	2012-05-01 21:05:45 By Ly Trong Hieu Ly
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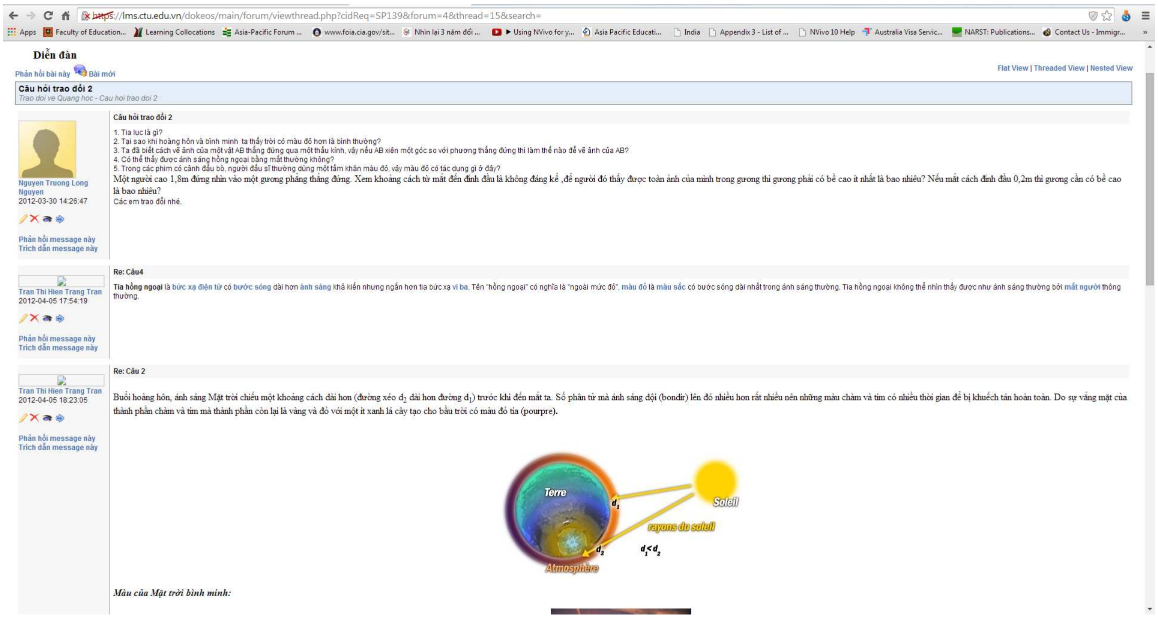
Thao luan cau hoi so 3: tai sao sinh vat bien co the phat sang vao ban dem?	0	35	Truong Hong Phi Truong	2012-05-01 00:11:44 By Truong Hong Phi Truong
Thao luan cau hoi so 3: tai sao sinh vat bien co the phat sang vao ban dem?	0	19	Truong Hong Phi Truong	2012-05-01 00:05:35 By Truong Hong Phi Truong
cau hoi trao doi 3	0	11	Son Thi Thuong Lien Son	2012-04-30 20:54:57 By Son Thi Thuong Lien Son
Câu hỏi thảo luận	0	8	Nguyen Thi Thuy Trang Nguyen	2012-04-30 19:06:18 By Nguyen Thi Thuy Trang Nguyen
câu hỏi trao đổi 2	1	24	Son Thi Thuong Lien Son	2012-04-30 14:13:49 By Son Thi Thuong Lien Son
câu hỏi trao đổi 2	0	21	Ta Cong Minh Nhut Ta	2012-04-30 12:08:33 By Ta Cong Minh Nhut Ta
Trả lời Bộ câu hỏi số 02	0	17	Nguyen Thanh Phong Nguyen	2012-04-30 11:47:25 By Nguyen Thanh Phong Nguyen
cau hoi trao doi 2	0	10	Nguyen My Ngoc Nguyen	2012-04-30 01:08:37 By Nguyen My Ngoc Nguyen
cau hoi trao doi 3	0	15	Nguyen My Ngoc Nguyen	2012-04-30 01:07:43 By Nguyen My Ngoc Nguyen
cau hoi trao doi 2	0	9	Nguyen My Ngoc Nguyen	2012-04-30 00:26:42 By Nguyen My Ngoc Nguyen
câu 2,4,5	0	13	Le Huu Nghia Le	2012-04-29 22:23:20 By Le Huu Nghia Le
Trả lời câu hỏi quang hình học	0	6	Le Huu Nghia Le	2012-04-29 22:19:28 By Le Huu Nghia Le
tra loi cau hoi trao doi 2	0	17	Le Thi Kim Cuong Le	2012-04-18 14:31:10 By Le Thi Kim Cuong Le
cau hoi thao luan	0	17	Tran Thi Ngoc Ngoan Tran	2012-04-17 10:05:44 By Tran Thi Ngoc Ngoan Tran
trả lời câu hỏi ôn tập quang hình học	0	17	Nguyen Kim Ri Nguyen	2012-04-10 00:00:51 By Nguyen Kim Ri Nguyen
câu hỏi trao đổi 2	0	20	Dao Thi Thuy Dao	2012-04-09 16:07:23 By Dao Thi Thuy Dao
Re: Cau 2	0	34	Dang Thao Vy Dang	2012-04-06 09:24:50 By Dang Thao Vy Dang

Tuesday, 24 June 2014



https://lms.ctu.edu.vn/dokeos/main/forum/viewthread.php?cidReq=SP139&forum=4&thread=15&search=

Diễn đàn

Phản hồi bài này | Bài mới — Flat View | Threaded View | Nested View

Câu hỏi trao đổi 2
Trao doi ve Quang hoc - Cau hoi trao doi 2

Nguyen Truong Long Nguyen — 2012-03-30 14:26:47

Câu hỏi trao đổi 2

1. Tia lục là gì?
2. Tại sao khi hoàng hôn và bình minh ta thấy trời có màu đỏ hơn là bình thường?
3. Ta đã biết cách vẽ ảnh của một vật AB thẳng đứng qua một thấu kính, vậy nếu AB xiên một góc so với phương thẳng đứng thì làm thế nào để vẽ ảnh của AB?
4. Có thể thấy được ánh sáng hồng ngoại bằng mắt thường không?
5. Trong các phim có cảnh đấu bò, người đấu sĩ thường dùng một tấm khăn màu đỏ, vậy màu đó có tác dụng gì ở đây?

Một người cao 1,8m đứng nhìn vào một gương phẳng thẳng đứng. Xem khoảng cách từ mắt đến đỉnh đầu là không đáng kể ,để người đó thấy được toàn ảnh của mình trong gương thì gương phải có bề cao ít nhất là bao nhiêu? Nếu mắt cách đỉnh đầu 0,2m thì gương cần có bề cao là bao nhiêu?

Các em trao đổi nhé.

Phản hồi message này
Trích dẫn message này

Tran Thi Hien Trang Tran — 2012-04-05 17:54:19

Re: Câu4

Tia hồng ngoại là bức xạ điện từ có bước sóng dài hơn ánh sáng khả kiến nhưng ngắn hơn tia bức xạ vi ba. Tên "hồng ngoại" có nghĩa là "ngoài mức đỏ", màu đỏ là màu sắc có bước sóng dài nhất trong ánh sáng thường. Tia hồng ngoại không thể nhìn thấy được như ánh sáng thường bởi mắt người thông thường.

Phản hồi message này
Trích dẫn message này

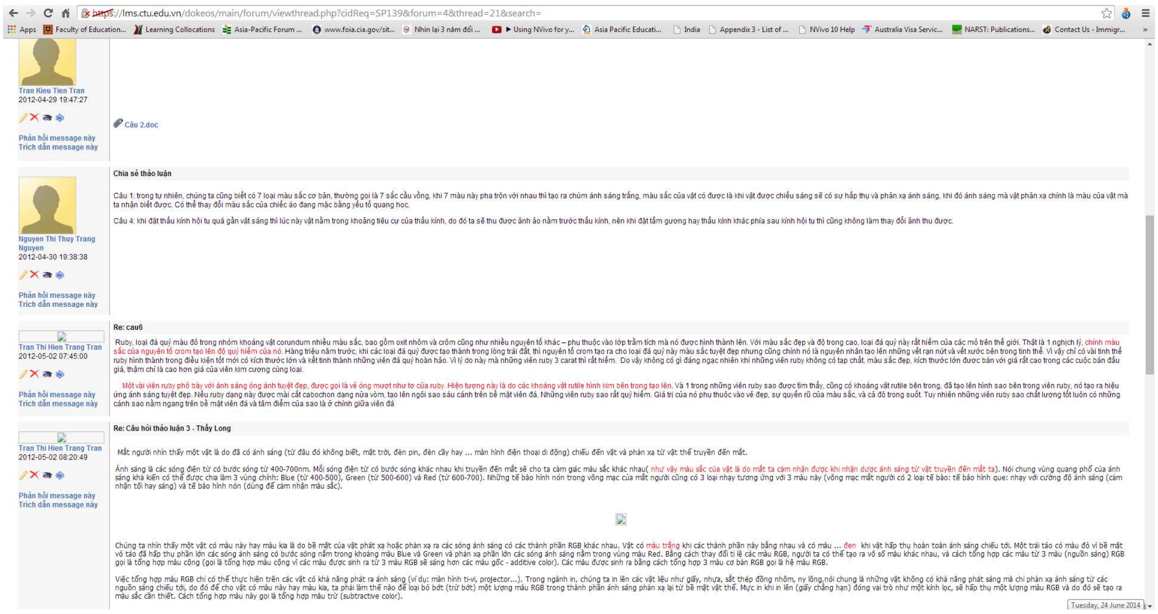
Tran Thi Hien Trang Tran — 2012-04-05 18:23:05

Re: Câu 2

Buổi hoàng hôn, ánh sáng Mặt trời chiếu một khoảng cách dài hơn (đường xéo d_2 dài hơn đường d_1) trước khi đến mắt ta. Số phân tử mà ánh sáng dội (bondir) lên đó nhiều hơn rất nhiều nên những màu chàm và tím có nhiều thời gian để bị khuếch tán hoàn toàn. Do sự vắng mặt của thành phần chàm và tím mà thành phần còn lại là vàng và đỏ với một ít xanh lá cây tạo cho bầu trời có màu đỏ tía (pourpre).

Màu của Mặt trời bình minh:

Phản hồi message này
Trích dẫn message này



https://lms.ctu.edu.vn/dokeos/main/forum/viewthread.php?cidReq=SP139&forum=4&thread=21&search=

Tran Kieu Tien Tran — 2012-04-29 19:47:27

Câu 2.doc

Phản hồi message này
Trích dẫn message này

Nguyen Thi Thuy Trang Nguyen — 2012-04-30 19:38:38

Chia sẻ thảo luận

Câu 1: trong tự nhiên, chúng ta cũng biết có 7 loại màu sắc cơ bản, thường gọi là 7 sắc cầu vồng, khi 7 màu này pha trộn với nhau thì tạo ra chùm ánh sáng trắng, màu sắc của vật có được là khi vật được chiếu sáng sẽ có sự hấp thụ và phản xạ ánh sáng, khi đó ánh sáng mà vật phản xạ chính là màu của vật mà ta nhận biết được. Có thể thay đổi màu sắc của chiếc áo đang mặc bằng yếu tố quang học.

Câu 4: khi đặt thấu kính hội tụ quá gần vật sáng thì lúc này vật nằm trong khoảng tiêu cự của thấu kính, do đó ta sẽ thu được ảnh ảo nằm trước thấu kính, nên khi đặt tấm gương hay thấu kính khác phía sau kính hội tụ thì cũng không làm thay đổi ảnh thu được.

Phản hồi message này
Trích dẫn message này

Tran Thi Hien Trang Tran — 2012-05-02 07:45:00

Re: cau6

Ruby, loại đá quý màu đỏ trong nhóm khoáng vật corundum nhiều màu sắc, bao gồm oxit nhôm và crôm cũng như nhiều nguyên tố khác – phụ thuộc vào lớp trầm tích mà nó được hình thành lên. Với màu sắc đẹp và độ trong cao, loại đá quý này rất hiếm của các mỏ trên thế giới. Thật là 1 nghịch lý, chính màu sắc của nguyên tố crom tạo lên độ quý hiếm của nó. Hàng triệu năm trước, khi các loại đá quý được tạo thành trong lòng trái đất, thì nguyên tố crom tạo ra cho loại đá quý này màu sắc tuyệt đẹp nhưng cũng chính nó là nguyên nhân tạo lên những vết rạn nứt và vết xước bên trong tinh thể. Vì vậy chỉ có vài tinh thể ruby hình thành trong điều kiện tốt mới có kích thước lớn và kết tinh thành những viên đá quý hoàn hảo. Vì lý do này mà những viên ruby 3 carat thì rất hiếm. Do vậy không có gì đáng ngạc nhiên khi những viên ruby không có tạp chất, màu sắc đẹp, kích thước lớn được bán với giá rất cao trong các cuộc bán đấu giá, thậm chí là cao hơn giá của viên kim cương cùng loại.

Một vài viên ruby phô bày với ánh sáng óng ánh tuyệt đẹp, được gọi là vẻ óng mượt như tơ của ruby. Hiện tượng này là do các khoáng vật rutile hình kim bên trong tạo lên. Và 1 trong những viên ruby sao được tìm thấy, cũng có khoáng vật rutile bên trong, đã tạo lên hình sao bên trong viên ruby, nó tạo ra hiệu ứng ánh sáng tuyệt đẹp. Nếu ruby dạng này được mài cắt cabochon dạng nửa vòm, tạo lên ngôi sao sáu cánh trên bề mặt viên đá. Những viên ruby sao rất quý hiếm. Giá trị của nó phụ thuộc vào vẻ đẹp, sự quyến rũ của màu sắc, và cả độ trong suốt. Tuy nhiên những viên ruby sao chất lượng tốt luôn có những cánh sao nằm ngang trên bề mặt viên đá và tâm điểm của sao là ở chính giữa viên đá

Phản hồi message này
Trích dẫn message này

Tran Thi Hien Trang Tran — 2012-05-02 08:20:49

Re: Câu hỏi thảo luận 3 - Thầy Long

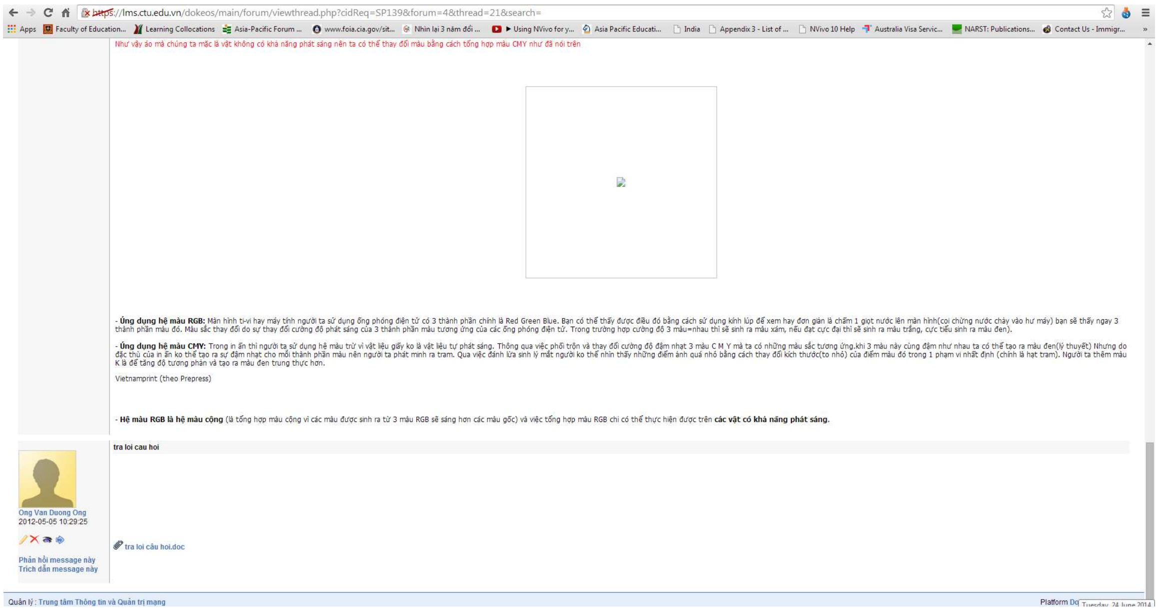
Mắt người nhìn thấy một vật là do đã có ánh sáng (từ đâu đó không biết, mặt trời, đèn pin, đèn cầy hay ... màn hình điện thoại di động) chiếu đến vật và phản xạ từ vật thể truyền đến mắt.

Ánh sáng là các sóng điện từ có bước sóng từ 400-700nm. Mỗi sóng điện từ có bước sóng khác nhau khi truyền đến mắt sẽ cho ta cảm giác màu sắc khác nhau(như vậy màu sắc của vật là do mắt ta cảm nhận được khi nhận được ánh sáng từ vật truyền đến mắt ta). Nói chung vùng quang phổ của ánh sáng khả kiến có thể được chia làm 3 vùng chính: Blue (từ 400-500), Green (từ 500-600) và Red (từ 600-700). Những tế bào hình nón trong võng mạc của mắt người cũng có 3 loại nhạy tương ứng với 3 màu này (võng mạc mắt người có 2 loại tế bào: tế bào hình que: nhạy với cường độ ánh sáng (cảm nhận tối hay sáng) và tế bào hình nón (dùng để cảm nhận màu sắc).

Chúng ta nhìn thấy một vật có màu này hay màu kia là do bề mặt của vật phát xạ hoặc phản xạ ra các sóng ánh sáng có các thành phần RGB khác nhau. Vật có màu trắng khi các thành phần này bằng nhau và có màu ... đen khi vật hấp thụ hoàn toàn ánh sáng chiếu tới. Một trái táo có màu đỏ vì bề mặt vỏ táo đã hấp thụ phần lớn các sóng ánh sáng có bước sóng nằm trong khoảng màu Blue và Green và phản xạ phần lớn các sóng ánh sáng nằm trong vùng màu Red. Bằng cách thay đổi tỉ lệ các màu RGB, người ta có thể tạo ra vô số màu khác nhau, và cách tổng hợp các màu từ 3 màu (nguồn sáng) RGB gọi là tổng hợp màu cộng (gọi là tổng hợp màu cộng vì các màu được sinh ra từ 3 màu RGB sẽ sáng hơn các màu gốc - additive color). Các màu được sinh ra bằng cách tổng hợp 3 màu cơ bản RGB gọi là hệ màu RGB.

Việc tổng hợp màu RGB chỉ có thể thực hiện trên các vật có khả năng phát ra ánh sáng (ví dụ: màn hình ti-vi, projector...). Trong ngành in, chúng ta in lên các vật liệu như giấy, nhựa, sắt thép đồng nhôm, ny lông,nói chung là những vật không có khả năng phát sáng mà chỉ phản xạ ánh sáng từ các nguồn sáng chiếu tới, do đó để cho vật có màu này hay màu kia, ta phải làm thế nào để loại bỏ bớt (trừ bớt) một lượng màu RGB trong thành phần ánh sáng phản xạ lại từ bề mặt vật thể. Mực in khi in lên (giấy chẳng hạn) đóng vai trò như một kính lọc, sẽ hấp thụ một lượng màu RGB và do đó sẽ tạo ra màu sắc cần thiết. Cách tổng hợp màu này gọi là tổng hợp màu trừ (subtractive color).

Tuesday, 24 June 2014



https://lms.ctu.edu.vn/dokeos/main/forum/viewthread.php?cidReq=SP139&forum=4&thread=21&search=

Như vậy áo mà chúng ta mặc là vật không có khả năng phát sáng nên ta có thể thay đổi màu bằng cách tổng hợp màu CMY như đã nói trên

- **Ứng dụng hệ màu RGB:** Màn hình ti-vi hay máy tính người ta sử dụng ống phóng điện tử có 3 thành phần chính là Red Green Blue. Bạn có thể thấy được điều đó bằng cách sử dụng kính lúp để xem hay đơn giản là chấm 1 giọt nước lên màn hình(coi chừng nước chảy vào hư máy) bạn sẽ thấy ngay 3 thành phần màu đó. Màu sắc thay đổi do sự thay đổi cường độ phát sáng của 3 thành phần màu tương ứng của các ống phóng điện tử. Trong trường hợp cường độ 3 màu=nhau thì sẽ sinh ra màu xám, nếu đạt cực đại thì sẽ sinh ra màu trắng, cực tiểu sinh ra màu đen).

- **Ứng dụng hệ màu CMY:** Trong in ấn thì người ta sử dụng hệ màu trừ vì vật liệu giấy ko là vật liệu tự phát sáng. Thông qua việc phối trộn và thay đổi cường độ đậm nhạt 3 màu C M Y mà ta có những màu sắc tương ứng.khi 3 màu này cùng đậm như nhau ta có thể tạo ra màu đen(lý thuyết) Nhưng do đặc thù của in ấn ko thể tạo ra sự đậm nhạt cho mỗi thành phần màu nên người ta phát minh ra tram. Qua việc đánh lừa sinh lý mắt người ko thể nhìn thấy những điểm ảnh quá nhỏ bằng cách thay đổi kích thước(to nhỏ) của điểm màu đó trong 1 phạm vi nhất định (chính là hạt tram). Người ta thêm màu K là để tăng độ tương phản và tạo ra màu đen trung thực hơn.

Vietnamprint (theo Prepress)

- **Hệ màu RGB là hệ màu cộng** (là tổng hợp màu cộng vì các màu được sinh ra từ 3 màu RGB sẽ sáng hơn các màu gốc) và việc tổng hợp màu RGB chỉ có thể thực hiện được trên **các vật có khả năng phát sáng.**

tra loi cau hoi

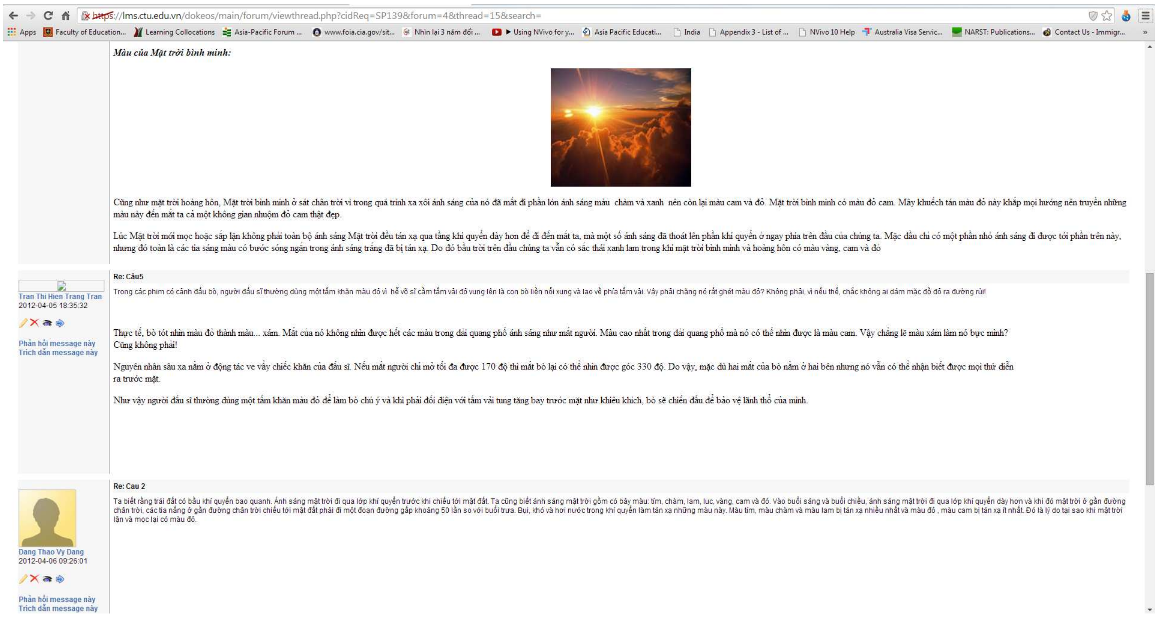
Ong Van Duong Ong
2012-05-05 10:29:25

Phản hồi message này
Trích dẫn message này

tra loi câu hoi.doc

Quản lý : Trung tâm Thông tin và Quản trị mạng

Platform Do Tuesday, 24 June 2014



https://lms.ctu.edu.vn/dokeos/main/forum/viewthread.php?cidReq=SP139&forum=4&thread=15&search=

Màu của Mặt trời bình minh:

Cũng như mặt trời hoàng hôn, Mặt trời bình minh ở sát chân trời vì trong quá trình xa xôi ánh sáng của nó đã mất đi phần lớn ánh sáng màu chàm và xanh nên còn lại màu cam và đỏ. Mặt trời bình minh có màu đỏ cam. Mây khuếch tán màu đỏ này khắp mọi hướng nên truyền những màu này đến mắt ta cả một không gian nhuộm đỏ cam thật đẹp.

Lúc Mặt trời mới mọc hoặc sắp lặn không phải toàn bộ ánh sáng Mặt trời đều tán xạ qua tầng khí quyển dày hơn để đi đến mắt ta, mà một số ánh sáng đã thoát lên phần khí quyển ở ngay phía trên đầu của chúng ta. Mặc dầu chỉ có một phần nhỏ ánh sáng đi được tới phần trên này, nhưng đó toàn là các tia sáng màu có bước sóng ngắn trong ánh sáng trắng đã bị tán xạ. Do đó bầu trời trên đầu chúng ta vẫn có sắc thái xanh lam trong khi mặt trời bình minh và hoàng hôn có màu vàng, cam và đỏ

Re: Câu5

Tran Thi Hien Trang Tran
2012-04-05 18:35:32

Phản hồi message này
Trích dẫn message này

Trong các phim có cảnh đấu bò, người đấu sĩ thường dùng một tấm khăn màu đỏ vì hễ võ sĩ cầm tấm vải đỏ vung lên là con bò liền nổi xung và lao về phía tấm vải. Vậy phải chăng nó rất ghét màu đỏ? Không phải, vì nếu thế, chắc không ai dám mặc đồ đỏ ra đường rùi!

Thực tế, bò tót nhìn màu đỏ thành màu... xám. Mắt của nó không nhìn được hết các màu trong dải quang phổ ánh sáng như mắt người. Màu cao nhất trong dải quang phổ mà nó có thể nhìn được là màu cam. Vậy chẳng lẽ màu xám làm nó bực mình?
Cũng không phải!

Nguyên nhân sâu xa nằm ở động tác ve vẩy chiếc khăn của đấu sĩ. Nếu mắt người chỉ mở tối đa được 170 độ thì mắt bò lại có thể nhìn được góc 330 độ. Do vậy, mặc dù hai mắt của bò nằm ở hai bên nhưng nó vẫn có thể nhận biết được mọi thứ diễn ra trước mặt.

Như vậy người đấu sĩ thường dùng một tấm khăn màu đỏ để làm bò chú ý và khi phải đối diện với tấm vải tung tăng bay trước mặt như khiêu khích, bò sẽ chiến đấu để bảo vệ lãnh thổ của mình.

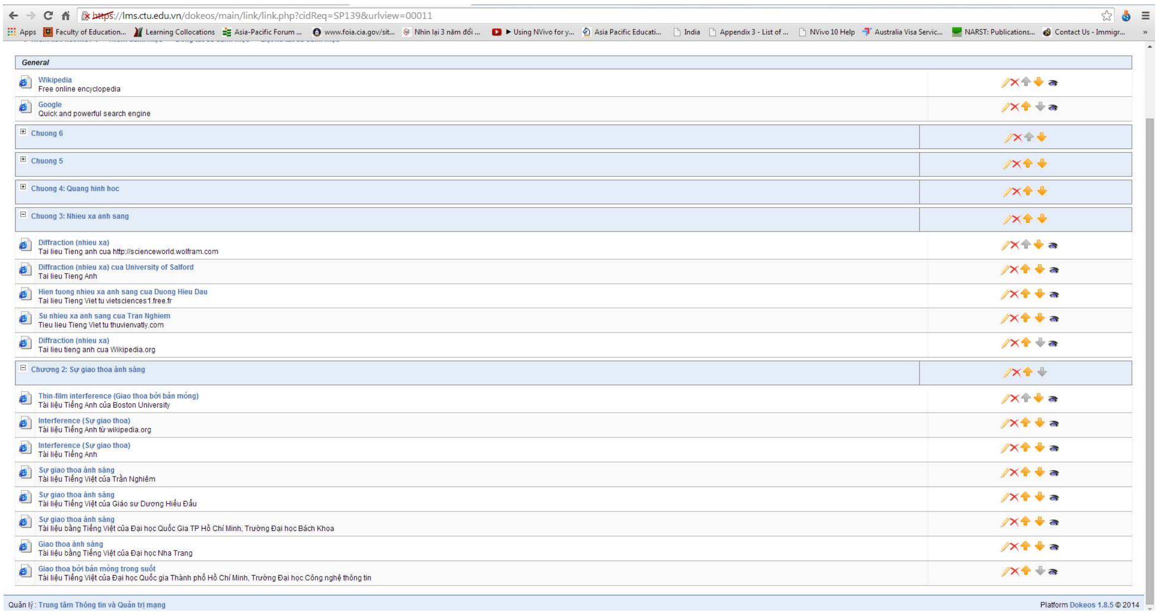
Re: Cau 2

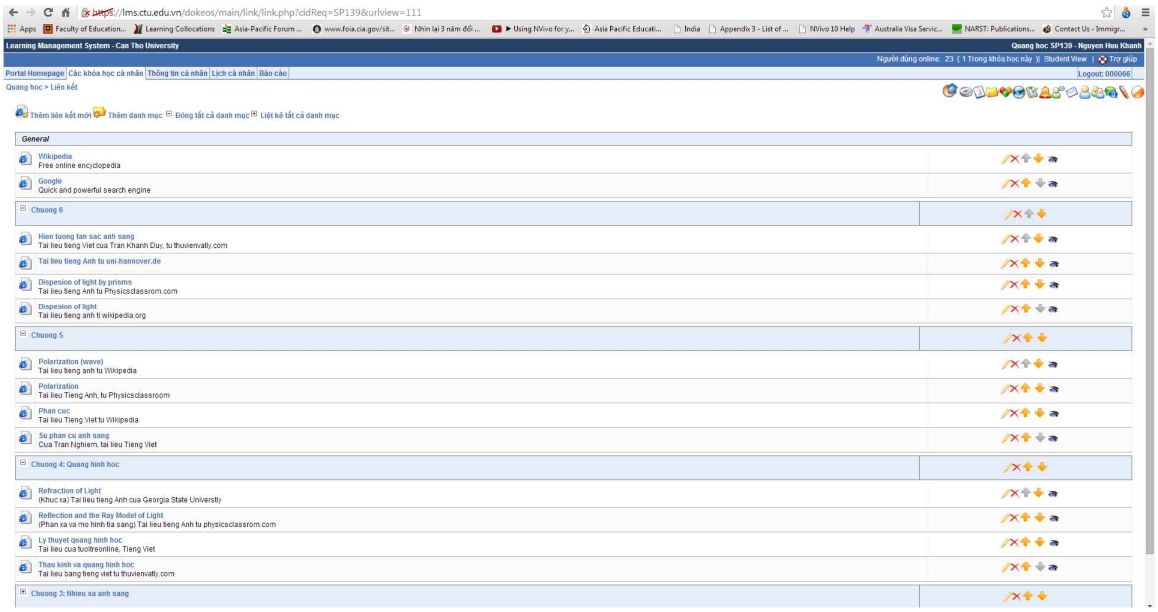
Dang Thao Vy Dang
2012-04-06 09:26:01

Phản hồi message này
Trích dẫn message này

Ta biết rằng trái đất có bầu khí quyển bao quanh. Ánh sáng mặt trời đi qua lớp khí quyển trước khi chiếu tới mặt đất. Ta cũng biết ánh sáng mặt trời gồm có bảy màu: tím, chàm, lam, lục, vàng, cam và đỏ. Vào buổi sáng và buổi chiều, ánh sáng mặt trời đi qua lớp khí quyển dày hơn và khi đó mặt trời ở gần đường chân trời, các tia nắng ở gần đường chân trời chiếu tới mặt đất phải đi một đoạn đường gấp khoảng 50 lần so với buổi trưa. Bụi, khó và hơi nước trong khí quyển làm tán xạ những màu này. Màu tím, màu chàm và màu lam bị tán xạ nhiều nhất và màu đỏ , màu cam bị tán xạ ít nhất. Đó là lý do tại sao khi mặt trời lặn và mọc lại có màu đỏ.

Links to optics websites





Appendix 6 Ethical Considerations

Ethics Approval from the University of Waikato

SUPERVISED GRADUATE/POSTGRADUATE RESEARCH PROJECTS

THE UNIVERSITY OF WAIKATO

Centre for Science & Technology Education Research

Human Ethics Sub-Committee

APPLICATION FOR ETHICAL APPROVAL OF

SUPERVISED GRADUATE/POSTGRADUATE RESEARCH PROJECTS

Date of Submission: November 4th, 2010

Name of applicant: **NGUYEN HONG NHUNG**

Contact address:

Centre for Science and Technology Education Research
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand

Contact phone number: 07 838 4466 Ext 8923

Email address: hnn3@students.waikato.ac.nz

Programme of study: PhD

Department/centre/unit: Centre for Science and Technology Education Research

Principal supervisor: **Assoc. Prof. JOHN WILLIAMS**

Current qualifications: Master of Science

Current employment:

Title of project: The Integration of ICT and Constructivist Learning Principles in Teaching Physics

Interest in topic

My Bachelor programme was on Physics-Education, and the master programme was on technology application in education and training. In addition, the experience of five years teaching Physics at Can Tho University also contributes well to the research.

Other personnel:

Dr. Michael Forret

Nguyen Thi Thuy Hang

SUPERVISED GRADUATE/POSTGRADUATE RESEARCH PROJECTS

d) that this application has been developed with my supervision and has my support. I have checked that all the information requested in the checklist below is included

e) I agree to support the student to follow the above mentioned procedures concerning the ethical conduct of this project.

Signature of supervisor: .... Date: 21/11/10

Signature of ~~supervisor~~: .... Date: 22/11/10

FSEW HR ETHICS COMMITTEE CHAIR

Letters to Participants

Nguyễn Hồng Nhung

Can Tho University
3/2 Street, Xuan Khanh Ward, Ninh Kieu District, Can Tho City, Vietnam
Phone: +84 989 700 226
E-mail: nhnhung@ctu.edu.vn

Centre for Science and Technology Education Research (CSTER)
The University of Waikato
Private Bag 3105, Hamilton 3240, New Zealand
Phone: +64 7 838 4466 Ext 8923

December 27th, 2011

Assoc. Prof. Nguyễn Thị Hồng Nam
Dean of School of Education
Can Tho University
3/2 Street, Xuan Khanh Ward,
Ninh Kieu District, Can Tho City, Vietnam

Dear Assoc. Prof. Nguyễn Thị Hồng Nam,

Re: Permission to Conduct Research at the Physics Department, The SoE, Can Tho University

I am a lecturer at Can Tho University and currently a PhD. candidate of The University of Waikato. New Zealand.

My dissertation is on "The Integration of Information Communication Technology (ICT) and Constructivist Learning Principles in Teaching Physics". The focus of the research is to develop an effective pedagogic model which integrates ICT and constructivist principles in the context of Can Tho University, Vietnam.

The study will involve students in the optics course which are run by the Physics Department of the School of Education. ICT in this context means the internet, software, multimedia resources and a learning management system (e.g. LMS). Two groups in the Physics Department of the SoE, CTU will be chosen. Optics' teaching and learning in the two groups will be supported by ICT and the developed pedagogic model will be used as a guide. One group will use all the applications of ICT such as the internet, software, multimedia resources and a learning management system (e.g. LMS). The other group will use the listed ICT applications, but not a learning management system.

The teaching will occur in Semester II, the school year 2011-2012, when the following information from the students will be accessed: test scores, feedback from questionnaires, interviews and records of in class observations throughout the semester on the students' learning. Involving in this study, the students will take pre-tests on Optics and critical thinking skills, and fill in a questionnaire at the beginning of the semester. They will also do the post-tests and answer a questionnaire at the end of this semester. It will totally take students about three hours to participate in the research; about two-third of the time will be at the first week of the semester when students' studying loads are light. Two observers will be invited to carry out observations at five points of time in the semester. A lecturer and the researcher will conduct the questionnaires and the tests. The summary of research proposal is attached.

The participants have the right to decline and to withdraw from the research at any time up until May 15th, 2012. They can also have their data deleted from the research by May 15th,

2012. For withdrawing, the participants will contact the researcher whose contact details are presented in the informed consent letter.

The data is kept confidential. Only the Optics test' scores will be identified with students as this is the normal assessment process for this course. Individual students can access to his/her Optics and critical thinking test scores. The data will be kept safely in a computer with password. The two supervisors can access the data for supervising purposes. The data will be used only for writing the dissertation, making presentations and publishing. The data is reported without the names, appearances and identity of the students

The research has been approved by the Human Research Ethics Committee of the Waikato University (see attachment). If you have questions about the study, please contact me (e-mail: nhnhung@ctu.edu.vn, phone: + 64 220 378 290 (NZ) or +84 989 700 226 (Vn). For further query, please contact Assoc. Prof. John Williams (email: jwilliam@waikato.ac.nz, phone: +64 7 838 4769).

I am very grateful if you could permit me to conduct the research. Your help is very much appreciated.

I am looking forward to hear from you.

Kind regards,

Nguyễn Hồng Nhung

P.S. I would like to show my thankfulness to you for your great support for my work at the university and my studying.

Assoc. Prof. Nguyễn Thị Hồng Nam
Dean of School of Education
Can Tho University
3/2 Street, Xuan Khanh Ward,
Ninh Kieu District, Can Tho City, Vietnam
E-mail: nhnam@ctu.edu.vn
Website: www.ctu.edu.vn

27 December, 2011

Nguyễn Hồng Nhung
Centre for Science and Technology Education Research (CSTER)
The University of Waikato
Private Bag 3105, Hamilton 3240, New Zealand
Phone: +64 7 838 4466 Ext 8923

Dear Nguyễn Hồng Nhung,

Re: Consent for Your Doctoral Research to Be Conducted at the Physics Department, the SoE

Your application package including the summary of your research proposal and the two letters of applying for permission has been examined carefully, and your application has been considered.

I am pleased to inform you that you are permitted to conduct the doctoral research on "the Integration of Information Communication Technology (ICT) and Constructivist Learning Principles in Teaching Physics" at the Physics Department of the School of Education at Can Tho University.

It is understood that:

1. The research is on teaching Physics (the Optics course) for tertiary students in the light of integrating ICT and constructivist & sociocultural principles. The teaching will occur in one semester.
2. The university in the research is voluntary.
3. The data collection is at the beginning, during and after the semester.
4. The data is kept confidential and will be used for writing dissertation, making presentation and publishing.
5. The data is reported without the name and identity of the students.

You are given the consent of doing the research on students of Optics course that are provide by the Physics Department of the School of Education at Can Tho University in one semester.

Yours sincerely,

Nguyễn Thị Hồng Nam

Nguyễn Hồng Nhung

Can Tho University
3/2 Street, Xuan Khanh Ward, Ninh Kieu District, Can Tho City, Vietnam
Phone: +84 989 700 226
E-mail: nhnhung@ctu.edu.vn

Centre for Science and Technology Education Research (CSTER)
The University of Waikato
Private Bag 3105, Hamilton 3240, New Zealand
Phone: +64 7 838 4466 Ext 8923

December 26th, 2011

[Name of lecturer]

Physics Department, the School of Education
Can Tho University
3/2 Street, Xuan Khanh Ward,
Ninh Kieu District, Can Tho City, Vietnam

Dear [name of lecturer],
Re: Inform the Research and Invite to Participate

I am a lecturer at Can Tho University and currently a PhD candidate of The University of Waikato, New Zealand.

My dissertation is on "The Integration of Information Communication Technology (ICT) and Constructivist Learning Principles in Teaching Physics". The focus of the research is to develop an effective pedagogic model which integrates ICT and constructivist principles in the context of Can Tho University, Vietnam.

The study will involve students in the Mechanics courses, which are run by the Physics Department of the School of Education. ICT in this context means the internet, software, multimedia resources, and a learning management system (i.e. LMS). Two groups in the Physics Department of the SoE, CTU will be chosen. Optics' teaching and learning in the two groups will be supported by ICT and the developed pedagogic model will be used as a guide. One group will use all the applications of ICT such as the internet, software, multimedia resources and a learning management system (e.g. LMS). The other group will use the listed ICT applications, but not a learning management system. The teaching will occur in Semester II, the school year 2011-2012, when the following information from the students will be accessed: test scores, feedback from questionnaires, interviews and records of observations on the students' learning.

In the research, students will do two tests on critical thinking skills which were designed by the test provider Insight Assessment in one and a half hours. Besides the normal test, they will do a pre-test in Optics in 45 minutes and fill in two questionnaires in about a half hour. It will totally take students about three hours to participate in the research; about two-third of the time will be at the first week of the semester when students' studying loads are light. Two observers will be invited to carry out observations at five points of time in the semester. A lecturer and the researcher will conduct the questionnaires and the tests.

The data is kept confidential. Only the Optics test' scores will be identified with students as this is the normal assessment process for this course. Individual students can access to his/her Optics and critical thinking test scores. The data will be kept safely in a computer with password. The two supervisors can access the data for supervising purposes. The data will be used only for writing the dissertation, making presentations and publishing. The data is reported anonymously.

I would like to invite you participate in this study as the lecturer who were mentioned above. The activities which you will involve in include:

- Working with me to understand the CSI model and implementing it into your teaching
- Designing the Optics tests
- Oganising the students to conduct the Optics tests, two critical thinking skills tests, the two questionnaires.
- Permitting two observers to observe students' learning activities and allowing video-recording the students' learning activities in your lectures at five points of time through the semester.

Your data will be kept confidentially. The data will be used only for writing the dissertation, making presentations and publishing. The data is reported without your names, your appearances and your identity.

The research has also been approved by the Human Research Ethics Committee of the Waikato University (see attachments).

You can decline to involve in the research. When participating, you can also withdraw from the research until April 1st, 2011.

If you have questions about the study, please contact me (e-mail: nhnhung@ctu.edu.vn, phone: + 64 220 378 290 (NZ) or +84 989 700 226 (Vn). For further query, please contact Assoc. Prof. John Williams (email: jwilliam@waikato.ac.nz, phone: +64 7 838 4769).

I am very grateful if you could involve in the research and would write me a letter which addresses that you will join this study. Your cooperation is very much appreciated.

I am looking forward to hear from you.

Kind regards,

Nguyễn Hồng Nhung

Research on "the Integration of ICT and Constructivist Learning Principles in Teaching Physics"

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Lecturer Participant Consent

I have read the letter informing me of the research. It is understood that:

1. My participation in the research is completely voluntary.
2. I have the right to decline and to withdraw from the research at any time until May 15th, 2012 and have my data deleted from the research by May 15th, 2012.
3. The data is kept confidential and will only be used for writing a dissertation, making presentations and publishing.
4. The data is reported without may name, appearance and identity.
5. If I have questions about the study, I will contact Nguyễn Hồng Nhung (e-mail: nhnhung@ctu.edu.vn, phone: +84 989 700 226). For further query, I will contact Assoc. Prof. John Williams (email: jwilliam@waikato.ac.nz, phone: +64 7 838 4769) or the dean of the School of Education Nguyen Thi Hong Nam (email: nhnam@ctu.edu.vn phone: 0918486086).

I sign this form to indicate my agreement to participate in the research which involves me in the activities described in the invitation letter.

Nguyễn Hồng Nhung

Can Tho University
3/2 Street, Xuan Khanh Ward, Ninh Kieu District, Can Tho City, Vietnam
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Centre for Science and Technology Education Research (CSTER)
The University of Waikato
Private Bag 3105, Hamilton 3240, New Zealand
Phone: +64 7 838 4466 Ext 8923

Dear students,

Re: Inform the Research and Invite to Participate

I am a lecturer at Can Tho University and currently a PhD. candidate of The University of Waikato, New Zealand.

I would like to invite you to participate in the doctoral research on "The Integration of Information Communication Technology (ICT) and Constructivist Learning Principles in Teaching Physics". The focus of the research is to develop an effective pedagogic model which integrates ICT and constructivist principles in the context Can Tho University, Vietnam.

The study will involve students in the Optics courses, which are provided by the Physics Department of the School of Education, in a student-centred approach using ICT. ICT in this context means the internet, software, multimedia resources, and a learning management system (i.e. LMS).

Two groups in the Physics Department of the SoE, CTU will be chosen. Optics' teaching and learning in the two groups will be supported by ICT and the developed pedagogic model will be used as a guide. One group will use all the applications of ICT such as the internet, software, multimedia resources and a learning management system (e.g. LMS). The other group will use the listed ICT applications, but not learning management system.Your participation will not adversely affect your performance.

The teaching will occur in Semester Two, the school year 2011-2012, when the following information from you will be accessed: test scores, feedback from questionnaires, interviews, some video records of your learning and in class observations carried out at five points of time through the semester by two observers. You have the right to decline involving in this study. In addition, when participating in the research, you also have the right to withdraw from the research and have your data deleted at any time up until May 15th, 2012. Your withdrawal and declination will not affect your test score since your test paper will be marked anonymously and confidentially.

It does not matter which group you belongs to, the research will not prejudice your grade in class. After getting the Optics test scores, you will be provided with the answer sheet of the test and your test paper so that you will be able to check the marking of your test.

Involving in the research, you will do two tests on your critical thinking skills which were designed by the famous test provider Insight Assessment. These test scores will let you know ability of your critical thinking. The critical thinking skills tests will totally take you about one and a half hours. You also do a pre-test in Optics in 45 minutes and fill in two questionnaires in about a half hour. In general, it will take you about three hours to participate in the research; about two-third of the time will be at the first week of the semester when your studying load is light.

The dean of School of Education at CTU has approved that this research is able to be conducted in Physics Department, the School of Education, Can Tho University. The research has been approved by the Human Research Ethics Committee of the Waikato.

I would appreciate if you could be involved in the research. If you have questions about the study, do not hesitate to contact Nguyễn Hồng Nhung (e-mail: nhnhung@ctu.edu.vn, phone: +84 989 700 226). For further query, please contact Assoc. Prof. John Williams (email: jwilliam@waikato.ac.nz, phone: +64 7 838 4769) or the Head of Physics Department, Ms. Dang Thi Bac Ly (email: dtbly@ctu.edu.vn phone: 0958 019 733).

Your participation is greatly appreciated.

I am looking forward to hear from you.

Yours sincerely,

Nguyễn Hồng Nhung

Vietnamese version of the letter to students

Nguyễn Hồng Nhung

Trường Đại học Cần thơ
Đường 3/2, Phường Xuân Khánh, Quận Ninh Kiều, Tp Cần Thơ
Điện thoại: +84 989 700 226
E-mail: nhnhung@ctu.edu.vn

Centre for Science and Technology Education Research (CSTER)
The University of Waikato
Private Bag 3105, Hamilton 3240, New Zealand
Phone: +64 7 838 4466 Ext 8923

Thân gửi các em sinh viên,

V/v: Thông tin về đề tài và mời tham gia nghiên cứu

Cô là giảng viên của Trường Đại Học Cần Thơ (ĐHCT) và đang làm nghiên cứu sinh tại Đại học Waikato, New Zealand.

Cô mời các em tham gia và đề tài nghiên cứu sinh của cô. Tên đề tài là *Ứng dụng công nghệ thông tin (CNTT) và nguyên lí dạy học kiến tạo và dạy Vật lí*. Đề tại này tập trung vào phát triển một mô hình dạy học, kết hợp CNTT và nguyên lí dạy học kiến tạo vào bối cảnh trường ĐHCT, Việt Nam.

Nghiên cứu này liên quan đến sinh viên của học phần Quang học. Học phần này sẽ được Bộ môn Vật lí của Khoa Sư phạm dạy, ứng dụng CNTT theo phương châm lấy sinh viên là trung tâm. CNTT trong bối cảnh này có nghĩa là internet, phần mềm, nguồn tư liệu đa phương tiện và hệ thống mạng hỗ trợ học tập LMS.

Hai nhóm học phần của Bộ môn Vật lí, Khoa Sư phạm – ĐHCT sẽ được chọn. Việc dạy học của hai nhóm này sẽ được hỗ trợ bởi CNTT và mô hình sư phạm sẽ được sử dụng như là kim chỉ nam. Một nhóm sẽ sử dụng tất cả các ứng dụng của CNTT như internet, phần mềm, nguồn tư liệu đa phương tiện và hệ thống mạng hỗ trợ học tập LMS. Nhóm còn lại sử dụng các ứng dụng vừa nêu, ngoại trừ hệ thống mạng hỗ trợ học tập LMS. Việc tham gia của các em vào đề tài nghiên cứu sẽ không ảnh hưởng xấu đến kết quả học tập của các em.

Việc giảng dạy sẽ được tiến hành vào học kỳ II, năm học 2011-2012. Các thông tin sau đây từ các em sẽ được sử dụng: điểm kiểm tra, phản hồi trên bản hỏi, phỏng vấn, các đoạn phim được quay tại lớp, quan sát trên lớp vào 5 thời điểm khác nhau bởi 2 quan sát viên. Các em có quyền từ chối, không tham gia nghiên cứu này. Hơn nữa, khi đã tham gia nghiên cứu, các em có quyền rút ra khỏi nghiên cứu và thông tin của các em sẽ được xóa bỏ. Việc rút khỏi nghiên cứu có thể được thực hiện vào bất cứ thời điểm nào, kể từ ngày em tham gia nghiên cứu đến hết ngày 15.05.2012. Việc em không tham gia vào nghiên cứu hay rút khỏi nghiên cứu sẽ không ảnh hưởng đến điểm kiểm tra của các em vì các bài kiểm tra sẽ được chấm bảo mật.

Dù bất kỳ em thuộc vào nhóm nào, các em sẽ không bị thiên vị về điểm. Sau khi có kết quả kiểm tra, các em sẽ được trả bài kiểm tra lại và được cho biết đáp án. Do đó, các em có thể kiểm tra xem điểm của mình đã được chấm chính xác chưa.

Tham gia vào nghiên cứu này, các em sẽ làm 2 bài kiểm tra về tư duy. Các bài kiểm tra này được thiết kế bởi công ty Insight Assessment nổi tiếng về kiểm tra. Kết quả kiểm tra tư duy sẽ cho các em biết khả năng tư duy bình luận của các em. Các em làm hai bài kiểm tra trong khoảng 1 giờ 30 phút. Ngoài ra, các em còn làm bải kiểm tra Quang học đầu vào trong 40 phút và trả lời 2 bản hỏi trong khoảng 30 phút. Tổng cộng, các em cần khoảng 3 giờ để tham gia vào nghiên cứu này. 2/3 thời gian này rơi vào tuần đầu của học kỳ khi các em chưa phải học bài nhiều.

Trưởng Khoa Sư phạm – ĐHCT đã phê chuẩn nghiên cứu này được thực hiện tại BM Vật lí, Khoa Sư Phạm – ĐHCT. Nghiên cứu này cũng đã được phê chuẩn bởi Hội đồng "Human Research Ethics Committee" của ĐH Waikato.

Cô mời các em sẽ tham gia vào nghiên cứu này. Nếu các em cần biết thêm về nghiên cứu, xin hãy liên hệ cô Nguyễn Hồng Nhung (e-mail: nhnhung@ctu.edu.vn, ĐT: +84 989 700 226). Để liên hệ cấp cao hơn, các em hãy hiên hệ Phó Giáo sư John Williams (email: jwilliam@waikato.ac.nz, ĐT: +64 7 838 4769) hay cô trưởng Bộ môn Dang Thi Bac Ly (email: dtbly@ctu.edu.vn, ĐT: 0958 019 733).

Cô rất mong là các em sẽ tham gia vào nghiên cứu này.

Trân trọng.

Nguyễn Hồng Nhung

Research on "the Integration of ICT and Constructivist Learning Principles in Teaching Physics"

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Students Participant Consent

I have read the letter informing me of the research. It is understood that:

Tôi đã được thông tin về nghiên cứu này và hiểu rõ rằng:

1. My participation in the research is completely voluntary.
   Việc tham gia của tôi vào nghiên cứu này là hoàn toàn tự nguyện.
2. I have the right to decline and to withdraw from the research at any time until May 15th, 2012 and have my data deleted from the research by May 15th, 2012.
   Tôi có quyền từ chối và rút ra khỏi nghiên cứu này bất kỳ lúc nào cho đến ngày 15/05/2012 và các dữ liệu liên quan đến tôi sẽ được xóa đi cho đến ngày 15/05/2012.
3. My academic performance will not be prejudiced because of my participation or my withdrawal.
   Kết quả học tập của tôi sẽ không bị sai lệch do việc tham gia hay rút khỏi nghiên cứu của tôi.
4. The data is kept confidential and will only be used for writing a dissertation, making presentations and publishing.
   Thông tin sẽ được giữ bí mật và chỉ dùng vào việc viết đề tài, báo cáo và xuất bản.
5. The data is reported without may name, appearance and identity.
   Thông tin sẽ được báo cáo không có tên, sự xuất hiện cũng như dấu hiệu để nhận biết tôi.
6. If I have questions about the study, I will contact Nguyễn Hồng Nhung (e-mail: nhnhung@ctu.edu.vn, phone: +84 989 700 226). For further query, I will contact Assoc. Prof. John Williams (email: jwilliam@waikato.ac.nz, phone: +64 7 838 4769) or the dean of the School of Education Nguyễn Thị Hồng Nam (email: nhnam@ctu.edu.vn phone: 0918486086).
   Nếu tôi cần hỏi thêm về nghiên cứu, tô sẽ liên hệ cô Nguyễn Hồng Nhung (e-mail: nhnhung@ctu.edu.vn, phone: +84 989 700 226). Nếu tôi có khiếu nại gì, tôi có thể liên hệ với PGS John Williams (email: jwilliam@waikato.ac.nz, phone: +64 7 838 4769) hoặc trưởng Khoa Sư Phạm Nguyễn Thị Hồng Nam (email: nhnam@ctu.edu.vn phone: 0918486086).

I sign this form to indicate my agreement to participate in the research which involves me in the activities described in the invitation letter.

Tôi ký dưới đây để đồng ý tham gia nghiên cứu và các hoạt động đã được mô tả

Appendix 7 Observers' scores

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	1	87.5
2	Morning	5.00	6.00	5.50	Teacher - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	5.00	4.50	Teacher - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	1	87.5
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	87.5
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	87.5
2	Morning	3.00	4.00	3.50	Student(s) - Learning Material(s)	Minute 10th-15th	1	87.5
2	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 20th-25th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	1	87.5
2	Morning	5.00	4.00	4.50	Student(s) - Student(s)	Minute 20th-25th	1	87.5
2	Morning	4.00	5.00	4.50	Student(s) - Student(s)	Minute 20th-25th	1	87.5
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	1	87.5

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	1	87.5
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	1	87.5
2	Morning	5.00	6.00	5.50	Teacher - Student(s)	Minute 20th-25th	1	87.5
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	1	87.5
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	1	87.5
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	87.5
2	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	87.5
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	87.5
2	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	1	87.5
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	1	87.5
2	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 30th-35th	1	87.5
2	Morning	6.00	6.00	6.00	Student(s) - Student(s)	Minute 30th-35th	1	87.5
2	Morning	6.00	6.00	6.00	Student(s) - Student(s)	Minute 30th-35th	1	87.5
2	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 30th-35th	1	87.5
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	1	87.5
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	1	87.5
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	1	87.5
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	1	87.5
2	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	1	87.5
2	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	1	87.5
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	87.5
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	87.5
2	Afternoon	3.00	2.00	2.50	Student(s) - Learning Material(s)	Minute 30th-35th	1	87.5
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	87.5
2	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	87.5

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	87.5
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	3.00	2.00	2.50	Student(s) - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	1	87.5
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	87.5
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	87.5
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	87.5
2	Afternoon	3.00	2.00	2.50	Student(s) - Learning Material(s)	Minute 40th-45th	1	87.5
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	87.5
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	87.5
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	2	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	2	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	2	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	2	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	2	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	2	98.6
2	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	2	98.6
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	2	98.6
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	2	98.6

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	2	98.6
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	2	98.6
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	98.6
2	Morning	3.00	2.00	2.50	Student(s) - Learning Material(s)	Minute 10th-15th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	2	98.6
2	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	2	98.6
2	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	2	98.6
2	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	2	98.6
2	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	2	98.6
2	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	2	98.6
2	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	2	98.6

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	2	98.6
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	2	98.6
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	2	98.6
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	2	98.6
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	2	98.6
2	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	2	98.6
2	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	98.6
2	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	98.6
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	98.6
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	98.6
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	98.6
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	2	98.6
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	2	98.6
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	2	98.6
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	2	98.6
2	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 40th-45th	2	98.6
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	2	98.6
2	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 40th-45th	2	98.6
2	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 40th-45th	2	98.6
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	2	98.6
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	2	98.6

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	98.6
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	98.6
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	98.6
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	98.6
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	98.6
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	98.6
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	98.6
2	Morning	7.00	6.00	6.50	Student(s) - Student(s)	Minute 10th-15th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	3	86.1
2	Morning	2.00	1.00	1.50	Student(s) - Student(s)	Minute 10th-15th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	3	86.1
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	3	86.1
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	3	86.1
2	Morning	6.00	5.00	5.50	Teacher - Student(s)	Minute 10th-15th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	3	86.1
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	86.1
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	86.1
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	86.1
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	86.1
2	Morning	2.00	1.00	1.50	Student(s) - Learning Material(s)	Minute 10th-15th	3	86.1
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	3	86.1
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	3	86.1

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	3	86.1
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	3	86.1
2	Morning	4.00	3.00	3.50	Student(s) - Student(s)	Minute 20th-25th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	3	86.1
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	3	86.1
2	Morning	5.00	6.00	5.50	Teacher - Student(s)	Minute 20th-25th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	3	86.1
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	3	86.1
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	86.1
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	86.1
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	86.1
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	86.1
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	86.1
2	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	86.1
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	3	86.1
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	3	86.1
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	3	86.1
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	3	86.1
2	Morning	5.00	6.00	5.50	Teacher - Student(s)	Minute 30th-35th	3	86.1
2	Morning	6.00	5.00	5.50	Teacher - Student(s)	Minute 30th-35th	3	86.1
2	Morning	1.00	6.00	3.50	Teacher - Student(s)	Minute 30th-35th	3	86.1
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	3	86.1
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	86.1
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	86.1

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	86.1
2	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	86.1
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	86.1
2	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	86.1
2	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	3	86.1
2	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	3	86.1
2	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	3	86.1
2	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	3	86.1
2	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	3	86.1
2	Morning	5.00	6.00	5.50	Teacher - Student(s)	Minute 40th-45th	3	86.1
2	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	86.1
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	86.1
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	86.1
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	86.1
2	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	86.1
2	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	86.1
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	98.6

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 20th-25th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	98.6
2	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	98.6

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	98.6
2	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	98.6
2	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	6.00	6.00	6.00	Student(s) - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	6	98.6
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	98.6
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	98.6
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	98.6
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	98.6
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	98.6
2	Afternoon	3.00	4.00	3.50	Student(s) - Learning Material(s)	Minute 30th-35th	6	98.6
2	Afternoon	6.00	6.00	6.00	Student(s) - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 40th-45th	6	98.6

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	7.00	7.00	7.00	Teacher - Student(s)	Minute 40th-45th	6	98.6
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	98.6
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	98.6
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	98.6
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	98.6
2	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	5.00	5.00	5.00	Student(s) - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	5.00	5.00	5.00	Student(s) - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	7.00	7.00	7.00	Teacher - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	7.00	7.00	7.00	Teacher - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	7.00	7.00	7.00	Teacher - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	7	95.8
2	Afternoon	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	95.8
2	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	95.8
2	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	95.8
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	95.8
2	Afternoon	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Afternoon	4.00	3.00	3.50	Student(s) - Learning Material(s)	Minute 10th-15th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	7.00	7.00	7.00	Teacher - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	7.00	7.00	7.00	Teacher - Student(s)	Minute 20th-25th	7	95.8
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	95.8
2	Afternoon	1.00	1.00	0.50	Student(s) - Learning Material(s)	Minute 20th-25th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	7	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	95.8
2	Afternoon	5.00	5.00	5.00	Student(s) - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	3.00	2.00	2.50	Student(s) - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 40th-45th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	95.8
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	95.8
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	95.8
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	95.8
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	7.00	6.00	6.50	Teacher - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 10th-15th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	94.4
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	94.4
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	94.4
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	8	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	8	94.4
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	94.4
2	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	94.4
2	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	94.4
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	94.4
2	Afternoon	3.00	2.00	2.50	Student(s) - Learning Material(s)	Minute 20th-25th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	2.00	1.00	1.50	Student(s) - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 30th-35th	8	94.4
2	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	94.4
2	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	94.4
2	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	94.4
2	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	94.4
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	1	95.8
3	Morning	2.00	3.00	2.50	Student(s) - Student(s)	Minute 20th-25th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	1	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	1	95.8
3	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	1	95.8
3	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	1	95.8
3	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	1	95.8
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	1	95.8
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	1	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	95.8
3	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	1	95.8
3	Morning	3.00	4.00	3.50	Student(s) - Student(s)	Minute 30th-35th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	1	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	1	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	1	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	1	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	1	95.8
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	1	95.8
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	1	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	1	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Morning	5.00	4.00	4.50	Student(s) - Student(s)	Minute 40th-45th	1	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	1	95.8
3	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 40th-45th	1	95.8
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	1	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	1	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	1	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	2	94.4
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	2	94.4
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	2	94.4
3	Morning	5.00	4.00	4.50	Student(s) - Student(s)	Minute 10th-15th	2	94.4
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	2	94.4
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	2	94.4
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	2	94.4
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	2	94.4
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	2	94.4
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	94.4
3	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	2	94.4
3	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 20th-25th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	2	94.4
3	Morning	2.00	3.00	2.50	Student(s) - Student(s)	Minute 20th-25th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	94.4
3	Morning	7.00	7.00	7.00	Teacher - Student(s)	Minute 20th-25th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	94.4
3	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	94.4
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	2	94.4
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	2	94.4
3	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 30th-35th	2	94.4
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 30th-35th	2	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 30th-35th	2	94.4
3	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	2	94.4
3	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	2	94.4
3	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	2	94.4
3	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	2	94.4
3	Morning	3.00	4.00	3.50	Student(s) - Learning Material(s)	Minute 30th-35th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	94.4
3	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	94.4
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	94.4
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	2	94.4
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	94.4
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	94.4
3	Morning	4.00	3.00	3.50	Student(s) - Learning Material(s)	Minute 40th-45th	2	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	94.4
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	3	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	3	95.8
3	Morning	3.00	2.00	2.50	Student(s) - Student(s)	Minute 10th-15th	3	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	3	95.8
3	Morning	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	3	95.8
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	3	95.8
3	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	3	95.8
3	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	3	95.8
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	3	95.8
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	95.8
3	Morning	2.00	3.00	2.50	Student(s) - Learning Material(s)	Minute 10th-15th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	3	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	3	95.8
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	3	95.8
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	3	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	3	95.8
3	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	95.8
3	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	95.8
3	Morning	6.00	5.00	5.50	Teacher - Student(s)	Minute 30th-35th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	95.8
3	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	3	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	3	95.8
3	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	3	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	3	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	3	95.8
3	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	3	95.8
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	3	95.8
3	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	3	95.8
3	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	3	95.8
3	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	95.8
3	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	95.8
3	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	95.8
3	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	95.8
3	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	95.8
3	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 40th-45th	3	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	5.00	5.00	5.00	Student(s) - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	5.00	5.00	5.00	Student(s) - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	3.00	2.00	2.50	Teacher - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	6	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	94.4
3	Afternoon	6.00	6.00	6.00	Student(s) - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	5.00	5.00	5.00	Student(s) - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	5.00	5.00	5.00	Student(s) - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	7.00	6.00	6.50	Teacher - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	6	94.4
3	Afternoon	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	6	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	4.00	3.00	3.50	Teacher - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	6	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	94.4
3	Afternoon	4.00	3.00	3.50	Student(s) - Learning Material(s)	Minute 40th-45th	6	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	2.00	3.00	2.50	Student(s) - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
3	Afternoon	3.00	4.00	3.50	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Afternoon	2.00	3.00	2.50	Student(s) - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	2.00	1.00	1.50	Teacher - Student(s)	Minute 30th-35th	7	94.4
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
3	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	8	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
3	Afternoon	3.00	2.00	2.50	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	3.00	4.00	3.50	Teacher - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	8	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 40th-45th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	8	95.8
3	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	8	95.8
3	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 40th-45th	8	95.8
3	Afternoon	1.00	2.00	1.50	Student(s) - Learning Material(s)	Minute 40th-45th	8	95.8
13	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	1	94.4
13	Morning	1.00	2.00	1.50	Student(s) - Student(s)	Minute 10th-15th	1	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	1	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	1	94.4
13	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	1	94.4
13	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	1	94.4
13	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	1	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	1	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	1	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	1	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	1	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	1	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	1	94.4
13	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	1	94.4
13	Morning	5.00	4.00	4.50	Teacher - Student(s)	Minute 20th-25th	1	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	1	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	1	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	1	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	1	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 30th-35th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Student(s)	Minute 30th-35th	1	94.4
13	Morning	7.00	7.00	7.00	Student(s) - Student(s)	Minute 30th-35th	1	94.4
13	Morning	7.00	7.00	7.00	Student(s) - Student(s)	Minute 30th-35th	1	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	1	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	1	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	1	94.4
13	Morning	7.00	7.00	7.00	Teacher - Student(s)	Minute 30th-35th	1	94.4
13	Morning	7.00	7.00	7.00	Teacher - Student(s)	Minute 30th-35th	1	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Morning	7.00	7.00	7.00	Teacher - Student(s)	Minute 30th-35th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 30th-35th	1	94.4
13	Morning	3.00	4.00	3.50	Student(s) - Student(s)	Minute 40th-45th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	1	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 40th-45th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 40th-45th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	94.4
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	94.4
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 40th-45th	1	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	2	93.1
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	2	93.1
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	2	93.1

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	2	93.1
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	2	93.1
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	2	93.1
13	Morning	5.00	6.00	5.50	Teacher - Student(s)	Minute 10th-15th	2	93.1
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	2	93.1
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	93.1
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	2	93.1
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	2	93.1
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 20th-25th	2	93.1
13	Morning	4.00	5.00	4.50	Student(s) - Student(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 20th-25th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	6.00	5.50	Teacher - Student(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	93.1

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 20th-25th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Student(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	4.00	4.50	Student(s) - Student(s)	Minute 30th-35th	2	93.1
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	93.1
13	Morning	6.00	6.00	6.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 30th-35th	2	93.1
13	Morning	3.00	4.00	3.50	Student(s) - Student(s)	Minute 40th-45th	2	93.1
13	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	2	93.1
13	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	2	93.1
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	2	93.1
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	2	93.1

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Morning	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	2	93.1
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	93.1
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	2	93.1
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	93.1
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	93.1
13	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	93.1
13	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	93.1
13	Morning	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 40th-45th	2	93.1
13	Morning	5.00	6.00	5.50	Student(s) - Learning Material(s)	Minute 40th-45th	2	93.1
13	Morning	1.00	1.00	0.50	Student(s) - Student(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	3	94.4
13	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	3	94.4
13	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	3	94.4
13	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	3	94.4
13	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	3	94.4
13	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	3	94.4
13	Morning	2.00	2.00	2.00	Teacher - Student(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	94.4
13	Morning	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	3	94.4
13	Morning	2.00	1.00	1.50	Student(s) - Student(s)	Minute 20th-25th	3	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	3	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	3	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	3	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	3	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	3	94.4
13	Morning	3.00	2.00	2.50	Teacher - Student(s)	Minute 20th-25th	3	94.4
13	Morning	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	3	94.4
13	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	3	94.4
13	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	3	94.4
13	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	3	94.4
13	Morning	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	3	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	3	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	3	94.4
13	Morning	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	3	94.4
13	Morning	3.00	2.00	2.50	Student(s) - Student(s)	Minute 30th-35th	3	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	94.4
13	Morning	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	3	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	94.4
13	Morning	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	94.4
13	Morning	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	94.4
13	Morning	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	3	94.4
13	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	0.50	Student(s) - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Teacher - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	93.1

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 10th-15th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	1.00	1.00	1.00	Student(s) - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	1.00	2.00	1.50	Student(s) - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	3.00	4.00	3.50	Teacher - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 20th-25th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	93.1
13	Afternoon	3.00	2.00	2.50	Student(s) - Learning Material(s)	Minute 20th-25th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	3.00	2.00	2.50	Student(s) - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	6	93.1

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	4.00	4.00	4.00	Teacher - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	3.00	3.00	3.00	Teacher - Student(s)	Minute 30th-35th	6	93.1
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	93.1
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 30th-35th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	2.00	3.00	2.50	Student(s) - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	6	93.1
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	93.1
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	93.1
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	93.1
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 40th-45th	6	93.1
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	4.00	3.00	3.50	Student(s) - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 10th-15th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	7	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 20th-25th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
13	Afternoon	4.00	5.00	4.50	Student(s) - Learning Material(s)	Minute 20th-25th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 30th-35th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 30th-35th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Afternoon	3.00	4.00	3.50	Student(s) - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 40th-45th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
13	Afternoon	5.00	4.00	4.50	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 40th-45th	7	94.4
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	3.00	3.00	3.00	Student(s) - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	6.00	6.00	6.00	Teacher - Student(s)	Minute 10th-15th	8	95.8
13	Afternoon	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8

Week	Group	Observer1 score	Observer2 score	Mean	Types of interaction	Observation	Period	Reliability
13	Afternoon	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
13	Afternoon	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
13	Afternoon	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
13	Afternoon	5.00	5.00	5.00	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
13	Afternoon	6.00	5.00	5.50	Student(s) - Learning Material(s)	Minute 10th-15th	8	95.8
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	2.00	2.00	2.00	Student(s) - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	5.00	5.00	5.00	Teacher - Student(s)	Minute 20th-25th	8	95.8
13	Afternoon	3.00	4.00	3.50	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
13	Afternoon	3.00	4.00	3.50	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
13	Afternoon	3.00	3.00	3.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8
13	Afternoon	4.00	4.00	4.00	Student(s) - Learning Material(s)	Minute 20th-25th	8	95.8