MASTER'S THESIS

Applying Constructivist Active Learning Theory in the Creation of Information Security Hands on Labs

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Abstract

The specific goal of our thesis is to try and find a way to increase the learning effectiveness and student throughput. Our course under study was a data communications course, which included network security. This course was taught at the Luleå University of Technology (LTU). In our thesis, we attempt to meet our goals via the application of Constructivist Active Learning Theory by creating information security hands on labs. In our work, we have followed constructivist principles concerning the studied distance education course. Active learning, in general, is often of the form of the practical application of related theoretical knowledge. Our study includes information collected from this course. In our study, these LTU students are learning theoretical knowledge, concerning computer networking and information security. In the previous, 2011 Information Security program, we were unaware to find even a single LTU course which actually required students to perform practical labs during the final examinations. Our hypothesis is that even if a University only wants to teach theoretical knowledge, we can increase the theoretical knowledge learning effectiveness via the application of Constructivist Active Learning Theory with practical hands on exercises.

In order to meet our thesis goals, we are following the principles of constructivism learning theory based on Action Design Research approach to find an answer to the main research question follows:

> Will we be able to increase the learning effectiveness and student throughput via the application of Constructivist Active Learning Theory by creating information security hands on labs?
>
> Note that we will follow the existing constructivist active learning principles, in our research.

One of the foundations of constructivism and constructionism is that active learning results in more effective learning than solely passive learning. Hands-on labs clearly make a course more active. Therefore constructivism and constructionism are well suited learning theories

for our thesis goal. Thus, our research is clearly properly grounded, with regard to past research and existing academic knowledge. Our focus is via the use of virtual or simulated hands-on labs, which can be used for local, distance and blended classes.

During ADR, different new factors emerged such as the need for students to be active during group sessions, the need for students to be present in most group sessions, for the teachers to act in two different roles, and for the assessment of students in final examination to be via the use of technical hands-on laboratories. In the final stage of ADR, we compare the student throughput and final grades of students in 2012 and 2013. The result has shown success in improvement of effectiveness in learning and student throughput, which we believe is due to applying our design principles as an E-learning model for “data communication with security course”. Moreover, we surveyed students about the new method which will be discussed in the following sections. Additionally, due to the application our new model, our results show that students feel more confidence to take the course examination and pass on time instead of taking the make-up examination or never completing the course.

Keywords: Constructivism learning process, E-learning model, Action Design Research, students interactions with each other, environment and teacher

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1 Summary of the Flow, of this Thesis

The flow of this thesis is presented, as follows:

1. **Summary of the Flow, of this Thesis:** This chapter.

2. **Introduction and Outline**: This chapter discusses how ICT has impacted teaching and learning. Recent developments in the learning strategies of two of the top rated worldwide Universities are presented. Knowledge gaps are discussed, concerning how to best apply ICT to teaching and learning. Constructivism learning theory is presented, with regard to the active learning approach as related to distance learning. We then present the principles of constructivism/constructionism learning theory, which we followed.

3. **Problem Domain, Objectives, Research Question and Motivations:** Some history, concerning the LTU blended course being studied is presented. The delimitation of our research is then presented. Our hypothesis is presented, which is the following. In order for LTU to meet their goal of educating "security engineers", LTU must also provide these students, with at least some, hands-on "security engineering" type practical labs. Then some motivation is presented, as to why our thesis has an impact, concerning how to educate "security engineers".

4. **Methodology:** We mention that our research is based on both qualitative and quantitative objectives. We mention that our research is based on the principles and research techniques of Action Design Research (ADR). We then present our IT artifact and methods of interaction, with the students.

5. **Constructionism learning theory as a learning approach:** We explain, in layman terms, ADR and our kernel theory constructivism/constructionism. We then provide the theoretical background, literature review and our learning theory approach. We also explain why the ADR approach is applicable, to help us meet the goals, of our thesis.

6. **Action design research:** We present the ADR approach and then show how we have followed the ADR approach, in our thesis. In the next four chapters, we explain the ADR staging and demonstrate how we have followed each of the ADR specific stages.

7. **Stage 1: Problem Formulation in ADR:** We explain this ADR stage and show how we followed it.

8. **Stage 2 in ADR: Building, Intervention, and Evaluation:** We explain this ADR stage and show how we followed it.

9. **Stage 3: Reflection and Learning:** We explain this ADR stage and show how we followed it.

10. **Stage 4: Formalization of Learning:** We explain this ADR stage and show how we followed it.

11. **Results:** We present the results of our study. We compare the previous results (without our changes) to the new 2013 results (which include our changes in the course). Our results were very favorable, with an increase of 100% student throughput.

12. **Discussion:** We discussed our initial constructivism principles and then mentioned how we changed the role of students, to become much more active, in a practical sense. We presented some results, which were very favorable, such as out 100% increase in student throughput performance. Over 50% of the students were always stimulated and encouraged by the teacher, in the teacher's new "mentor" role.

13. **Conclusion:** We discuss our main thesis goal and show how we achieved our thesis goal. We also raise the issue, in that LTU's decision to not require students to attend any live lectures makes it more difficult to meet our required goal, of more active learning. Our recommended future work is discussed, including a recommendation for LTU to use MOOC tools and methodologies, in LTU's courses, which are not actually MOOC courses.

14. **Appendix:** We present and analyze the quantitative data that was collected during our thesis.

15. **Tables:** We organize our literature review in a concept-centric manner. We also structure the table, by identification of the key concepts.

16. **References:** We provide references, to support all of our thesis claims.

2 Introduction and Outline

The growth in information and communication technology (ICT) has resulted in new ways of interactions by diminishing the time and place requirements in teaching and learning (Saarinen, L. 2012). In the time of growth for technology via internet, E-learning is a new paradigm for modern educational institutions and many universities to provide online services for students around the world. E-learning has the grow rate of 35.6% in the world but still there are many failures in the current learning system ([Sun, Pei-Chen 2008] and [Hassanzadeh, Alireza 2012]). Giga Information Group released that, nearly 75% of the 129 top US universities use e-learning systems (Wang, Wei-Tsong 2009), so this huge number shows the tendency of many top universities to have an evolution in changing the traditional learning to e-learning preference. One of the most popular methods of e-learning is attending online courses (Monahan, Teresa 2008). Online learning or distance learning is a method which delivers the synchronous and asynchronous exchange of resources over ICT technology (Oncu, S. 2011). Applying technology to distance learning and virtual laboratories helps higher institutions increase the number of students who can be geographically dispersed (Ma, J. 2006). Many universities and educators, implement virtual classes in order to accelerate the pace of their studies, provide accessibilities to needed resources, provide equal accessibility to education for remote students and provide students with more flexibility in their education experiences.

For example, two famous Universities, Massachusetts Institute of Technology (MIT) and Harvard University and are rated as top worldwide Universities (# 1 and # 3 respectively). EdX is a non-for-profit online learning enterprise founded by Harvard University and MIT. They have put in a combined total of 60 million USD in order to develop online distance and blended education ICT tools. So it is clear that the top worldwide universities understand that major changes are needed in order to develop the next generation of ICT based education. On March 14th, 2013, edX released their open source Learning Platform tools, which is called XBlock SDK, which is being used to develop a new edX LMS. XBlocks allow course authors to easily combine pieces as small as a paragraph of text, an image, a video, a

multiple choice question or as large as a section or an entire course. Sweden's Karolinska Institute has joined as an official member of Edx.

Pearson Publishing is a world leader in publishing books, course book and course material. Pearson Publishing has been collaborating with Todd Booth on their next generation of virtual lab products, which will include the ability to assess and examine students' performance and to report the class performance information to their teacher.

Our hypothesis was that via active learning, we can improve student satisfaction and effective learning. A core of our research is an IT artifact. We will describe one IT artifact which helped improve student satisfaction and effective learning, which is a self-learning software program developed by Pearson Education. We are not interested in improving student satisfaction, on its own. Rather our hypothesis is that there is a correlation between student satisfaction and the amount of effort that a given student puts into the course. Our hypothesis is that the more satisfied with a course a given student is, the more effort that the student will put into that course. Further, our hypothesis is that the more effort a student puts into a course, the better that they will perform. There is a relation between our design principles and our hypothesis. It is via our design principles, which includes our recommended active learning approach, with the self-learning IT artifact, that we can show the effects of our hypothesis.

Our self-learning software program embodied our design principals by allowing students to be active in their learning (as they used the program).

Here is how our self-learning artifact embodied our design principals. By using the self-learning program the students were more active. By being more active, our students were following the constructivism principles.

Our general design principles, from the very beginning, were generally to use general constructivism principles. As we progressed in our research, we then came up with our own more refined and focused principles, such as to have the teacher act as more of a tutor and to have the student be active, via our self-learning artifact. Many design related issues

emerged during the development of our thesis, which are addressed in this paper. For example, we wanted many students to be active during the lectures however students were not required to attend any lectures. Even when students attended lectures, via the Internet, they often didn't have a microphone and thus, could not fully participate. During our thesis process we came up with more specific principles to address these issues. For example, we came up with a new specific design principle, to require students to attend lectures.

We also followed the ADR process. We were interested to use DR, but we agree that the ADR approach to DR, had advantages, with regard to our particular research goals. More specifically, we felt that the ADR approach would allow us to pay more attention to the organization, as compared to a DR only approach. The result of using the ADR process assisted us in discovering some emerging issues, which we don't believe would be discovered, had we used the older DR only approach.

It should be pointed out that we did not create design principles. We applied design principles based on our application of ADR, constructivism and constructionism. Further we applied these in a more specific and perhaps very unique environment.

Throughout this thesis, we discuss the ADR, constructionist and constructivism principles which we followed. Note that we did not follow each and every ADR, constructionist and constructivism principle. We provided the motivation concerning the principles we followed, in this thesis. For the principles that we did not follow, our reason was that this paper is only a thesis and we had limited time. Therefore we did not have time to address each and every theoretically possible design aspect. There is another issue. There is not yet any official paper, which makes it clear which are all of the academically agreed principles of ADF, constructionism and constructivism. Therefore if one were to cover all of the principles, which are perhaps considered as official, at least by some academics should be in a literature review paper, than a thesis such as we have presented. The reason is that to perform a proper literature review would greatly distract from the goals and activities of our thesis.

2.1 Virtualization in the online learning process

To better understand these changes in learning models, as used in higher education and distance learning, longitudinal studies are needed. The use of ICT to contribute to the learning process requires a complete research of actors, such as teachers and students. To improve effective learning, the ICT needs to be applied in the right way. There is a current knowledge gap in the area of applying technology to the learning processes. This gap justifies that researchers should perform broad research on technology, as used in distance education. This requires analysis of the interactions between these actors, in order to better create a usable theoretical model for practitioners. Only then, will the practitioners be in a better position to properly implement distance courses, via ICT. Furthermore, Dalgarno believes that "technology itself does not cause learning to occur but can afford certain tasks that may result in learning" (Dalgarno, B. 2010). As he said, one of the most important benefits of virtual environments is simulation of the real world for learners and interaction of learners with objects in a virtual learning environment. This may require learners to demonstrate dynamic behavior, in order to construct learning objects via personal knowledge iteratively. This will help them to undertake experimentations in cognitive constructivist learning theories (Dalgarno, B. 2010). So, a paradigm shift, as a revolution has occurred between ICT and learning processes, which has resulted in a fundamental changes in improved course design. Simultaneously, improvements in tests, quizzes, chats, simulations, discussions, forum and assignments have been introduced.

Consequently, by increasing the number of educators who implement virtual environments for education, there becomes a more serious need to consider the appropriate pedagogical approaches to maximize the effectiveness of learning. This may require us to re-design the traditional classroom structure, in which the teacher normally has the primary role (Girvan, Carina 2010). Consequently, many researchers tend to substitute those pedagogical approaches which have unique characteristics and potentials by simply using technology as a device to reach higher efficiency. Based on what Savin-Baden says, we as researchers, who

want to improve the pedagogical approaches along ICT and virtual world, need to reconstruct and reconsider the relationship between pedagogy and virtual world technology in order to find appropriate pedagogies which could leverage the efficiency in e-learning (Savin-Baden, M. 2008). Efficiency in e-learning can be expressed by knowledge building or by construction of new knowledge which concludes with authentic problems, self-organization, monitoring, creation of artifacts to collect knowledge (Girvan, Carina 2010).

2.2 Active learning as a one principle of Constructivism learning theory

One of the famous approaches of active learning is constructivism. Constructivists view correlates with the philosophy of distance education and let learners play the important role to choose goals, methods and strategies based on their responsibilities and simultaneously allow them to have participation and collaboration in the learning process. Subsequently, constructivist/constructionist views have the potential need to use information technology based learning and the best substitution for deterministic teacher-controlled model of distance learning in contextualized environment (Aqda, M.F. 2011).

2.3 Outline

The master thesis is organized as following. The first chapter introduces online/distance learning and the importance of this topic in the new learning system among top universities of the world. Chapter two introduces the problem domain and MSc information security program as a distance program, the current status as of 2012-2013, research questions of the thesis, and the motivation and objectives of thesis. Chapter three describes the methodology and the research approach, principles of constructivism/constructionism and four steps of action design research. Chapter four describes the first stage of action design research (problem formulation). Chapter five describes the second stage of ADR: Building, Intervention, and Evaluation which includes literature review, and the methodology for having a structured literature review. Chapter six describes the third stage of ADR which is Reflection and Learning and measurement of satisfaction and feedback of students concerning the new model. Chapter seven describes the fourth stage of ADR which is Formalization of Learning and defines the components of visualization according to Dr.

Sanford Gold. In Chapter eight we compare the final results and throughput of students in 2012 and 2013. Chapter nine describes the Discussion. Chapter ten describes Conclusions, Further Research, and Knowledge Contribution and builds a new theory based on Gregor.

The chapters which show how we follow the ADR process, engrain and embed the principals is found in chapters 7-10. Before analyzing these, one should first read the preceding chapters, in order, paying specific attention to our design principles.

3 Problem Domain, Objectives, Research Question, Motivations

3.1 MSc Information Security Program at LTU

The success of LTU's MSc Information Security program (InfoSec Program) partially depends on the number of students who join the program and graduate from the program. LTU provides the possibility for students to take InfoSec Program courses online and makes it possible for students from anywhere and without considerations of time zone, to join the Program. Distance learning allows students to have more flexibility and autonomy in the educational systems and be free of time and place limitation (Grant, L K. 2003). It also changes education in a way that each individual can control their own pace of learning. Consequently, e-learning provides cost effectiveness, flexibility of access, and just in time delivery for LTU ([Loots et al., 1998] and [Sambrook, 2003]).

LTU has offered the InfoSec Program, as a distance program since 2007. LTU makes it is possible for students to attend live lectures on campus or via the Internet. So, students only need to have an internet connection and a computer to join to the live sessions. Students always have the option to see the recorded sessions instead of attending the live sessions. Via interviews we have learned that many students are satisfied with the facilities and the quality of distance classes. Students have accessibility to the Fronter Learning Management System (LMS) to hand-in their assignments, access the recorded sessions and view various course contents. However, via our interviews many other students have indicated that the distance education course was not very interactive. Our study shows that student throughput can be increased by making the students more active in the learning process. Perhaps LTU was unaware of the relationship between active learning and student throughput. As part of our ADR, we suggested that LTU allow teachers to require students to attend some or most live group sessions. LTU agreed and LTU has decided to change the Program Description, based on our input. LTU will change the Program Description to allow some or all classes to require students to attend live group sessions (perhaps via the Internet).

Wang believes, there is not only one factor of user/students' satisfaction in measurement of success in e-learning pedagogy, but there are other factors such as service quality, pedagogical approach, system quality, information quality and user intention in measurement of success in e-learning pedagogy (Wang, Wei-Tsong 2009).

3.2 Scope of our research and Delimitation

First the scope will be presented. The scope of the problem is limited to University programs, which are technical MSc (Masters in Science). Within MSc programs, this thesis is limited to courses which prepare students to become engineers, who will be working in the field, doing design, configuration, and/or management of technical ICT tools.

The University under study was Luleå Technology University (LTU). The MSc Program under study was the 2012 MSc Information Security Program. In the program handbook[1], it specifically states that this Program will prepare students to work as an "information security engineers". However none of the courses require students to actually perform any hands-on labs, which are required for the students to master practical skills. Without learning these practical skills, the students simply can't master the required knowledge, to become "information security engineers".

Further, it is simply not possible for students to learn how to become a computer network security engineer unless they first learn the basics of computer network engineering (for example the topic of IP addressing knowledge which is required to understand Firewalls). In the 2010 InfoSec program curriculum, the required course D0025N, Data Communications with Security, did teach students the knowledge, to become computer network engineers.

However LTU decided to drop this computer network engineer course and replace it with an "Information Security Research" course.

[1] http://www.ltu.se/cms_fs/1.25162!/handbook_information_security.pdf

LTU has a program goal to become a world class education. The LTU Program is a two year program. Out of the two year (120 credits) program, the following required courses are focused to provide technical and practical knowledge, for students who wish to become security engineers:

LTU is seriously considering adding back the requirement for students to learn computer network engineering. In the meantime, this course is an optional elective, in the InfoSec Program. This course started in January, 2013. So we decided to use this specific course, as the studied course, to introduce hands-on labs and then to collect data. The teacher was Todd Booth, who taught the same exact course the year before. The main different in this 2013 course would be the introduction of hands-on labs, in order to test our hypothesis which will introduced in following parts.

3.3 Here are some reasons that we decided to choose this topic as our master thesis:

1. **Lack of adequate hands-on exercises in physical or virtual laboratory for data communication and security course**

LTU campus and distance students had no access to virtual lab equipment for data communication and security course. So, students had no lab assignments to improve their technical skills. However, in the data communication and security course there should be some hands-on lab assignments to help students prepare to become networking security engineers. As we gathered data through observations and interviews between students, there is some dissatisfaction among students because of the lack of equipped laboratories to do hands-on assignments and the satisfaction is not concerning quality of ICT or quality of communication with teacher (Krsmanovic, M. 2012). Hands-on labs are only one aspect of interactive learning.

2. Lack of interactivity and active learning in data communication and security course

Having passive students, via the current pedagogy approach of learning process, limits the students' ability to be a part of the learning process. The main responsibility of transference of new knowledge is via the teacher in his/her active role. The teacher is responsible for course content delivery and requires some homework by deadlines as paper-based assignments. So, the students are mostly passive in each lecture and act as silent receivers of knowledge and finally to pass the course, they have to do assignments and take exam at the end of semester. However hands-on labs were not part of the examination process. It is interesting that we have found the implementation of teaching and learning process implementation is based on "Knowledge Building" at handbook of LTU. The passive role of students based on Rovai may cause some other issues such as time limitation, lack of clear feedback from instructors, limited accessibility to materials and to teachers, feeling of isolation can effect negatively on students' perception and cause frustrations and anxiety and finally dissatisfaction in students (Rovai, A.P. 2004).

If we draw a diagram of the current learning process at data communication and security course which is a fundamental course to obtain technical experiences, we have to draw the teacher in the center, in order to show the only active agent in learning process. We also show the routine passive role of the students in a closed loop. As shown in the diagram 1, there is no interactivity and there are no hands-on exercises for students.

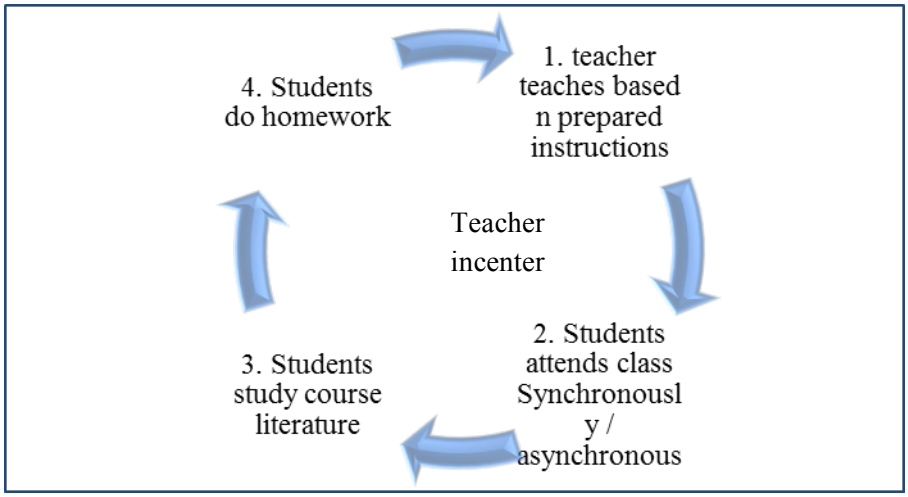


Figure 1 an ordinary class for data communication and security course

3. Lack of technical skills to become Information Security Engineers

Via the InfoSec Program Manual, LTU has promised students, that they would be educated as Info Sec engineers. One issue at LTU is the apparent discontinuity between needs for security engineers in the job market and the academic courses that are taught in the InfoSec Program.

Without practical real-world hands-on experience, in security, InfoSec students are unable to integrate knowledge material and technology (Yang, T.A. 2004). Attending classes by students offline or online is not enough to meet the technical requirements and obtain the appropriate proficiency as security engineers, in the technical field of ICT.

3.4 Statement of the Research Question

Systematic searching concerning a specific topic is called research. Scientific research defines problems, formulates hypothesis, collects and evaluates data and finally reaches to the

conclusion. The final result can be shown in form of generalization for theoretical formulation or solutions regarding to specific problem:

Which design principles should be followed, in order to implement an InfoSec lab, in accordance with the constructivist active learning principles? This will help us reveal an appropriate initial design theory.

3.4.1 Sub-questions in regards of main research question:

Sub-question1: How can we follow constructivism principles to establish e-learning model for an Information Security course?

Sub-question2: Which design principles do we need to follow, in order to implement an Information Security course via constructivism?

3.5 Objectives of Our Research

The main purpose of doing research is discovering answers for question(s) in form of scientific procedures. In fact, every successful research must uncover some hidden facts or find new facts in related to the topic. We divided our objectives of our master thesis as follows:

1. In order to get a better conceptual understanding of active learning for technical distance courses such as data communication with security course;
2. To clarify the characteristics of having active learning via distance learning by adding hands-on laboratories in the course content;
3. To find relationships between available principles of active learning and our hypothesis;

3.6 Motivation for this Research

One hypothesis is that the addition of hands-on labs, will improve the learning effectiveness and student throughput. To answer the fundamental question, "why do we undertake this research"? We divided our motivations as a list in the following:

1. Increase understanding as to why there is a lack of more active learning in technical courses, which are, for example, part of the LTU MSc InfoSec Program
2. Desire to get closer to the concept of collaboration and interaction of students in distance learning
3. Desire to increase experience for students, who wish to become Info Sec engineers. Note that in the Program Manual, LTU claims that students will be prepared to become security engineers
4. Desire to produce an e-learning model for data communication and security course that will result in an increased throughput of students
5. Desire to produce an e-learning model for data communication course that increase effectiveness in distance education via active learning
6. Desire to expand (or generalize) our model to similar technical courses

3.7 Significance of the Research Question

If we are able to help improve the learning effectiveness and student throughput, via our active learning approach, this would be helpful to all Universities which are teaching technical courses. So if we can obtain good results, our research is very significant. We have also obtained the input from our Swedish Defense supervisor, who believes that our research has practical value to the Swedish Defense force.

3.8 Claims Concerning the Research Question

Our claim or hypothesis is that an increase in active learning will, in turn, improve active learning and improve student throughput. In this part we refer to Professor Päivärinta's paper which has shown that there are few pedagogical approach of learning in higher education (Iqbal, S. 2012, Päivärinta, T.)

3.9 What is our hypothesis?

Our hypothesis was that we could increase the effective learning and increase the throughput of students, via the introduction of hands-on lab exercises based on constructivism learning theory as a systematic pedagogic approach of learning.

3.10 What is new in our Research?

During this thesis, we have reviewed a large number of academic papers. We were unable to find any academic papers which have used the ADR approach when combined with constructivism and constructionism. Therefore our paper is unique, or at least a more specific application of more generalized approaches.

4 Methodology

This chapter also includes the research process and research method.

4.1 Methodology Process and Type of Research

Qualitative research is a type of research which explores to understand the meaning of social or human problems in group or individually. Hence, quantitative research is testing objectives of relations between variables by testing theories (Cresswell). Our research is applicable to express phenomena in both types of qualitative and quantitative terms. We have students' behavior and feedback as our qualitative phenomena. So, we use some techniques such as observation, doing literature review, writing and recording diary, and review mails and feedbacks of students to know how students think about the new model of e-learning. Also, we have quantitative data through some data collection techniques such as surveys. Based on Cresswell, it is easier to collect and analyze both types of qualitative and quantitative data. In fact, Action design research provides procedures for researcher to merge qualitative and quantitative data in order to reach comprehensive analysis of the research problem and it requires researchers to collect both types of data at the same time and integrate them, in order to achieve the overall research goals.

4.2 Research Approach

The approach of our research is ADR or Action Design Research which is self-reflective enquiry and is taken by participants in social or educational situation to improve the rationality of own educational or social practices, situations in which practices are carrying out and their understanding of these particular practices.

4.3 What is our IT Artifact?

Our IT artifact is an e-learning model for data communication with security course which was and will be one of fundamental technical courses at MSc InfoSec at LTU. We want to improve

the pedagogical approach to this course by engaging students more actively in the process of teaching and learning technical knowledge.

4.4 Research Techniques

Research techniques are tools and instruments which we use to perform research operations such as data recording, literature review, observations and ext. We have chosen questionnaires, open-ended questions, surveys and observation as our main techniques of data collection since we have collected both qualitative and quantitative data.

We need to have different techniques of data collection due to the following reasons:

1. What is the effect of our new e-learning model on student performance?
2. Does the new e-learning model provide a more effective learning environment for the students? The same teacher taught the same course last year (2012). The course syllabuses (and thus goals) are the same for both 2012 and 2013. We will therefore compare the students' results in 2012 to the new 2013 results. The main high level change in the course was the use of our new e-learning model in combination with the constructivism learning theory. Some low level changes were the new use of a virtual simulator and a new teaching approach based on constructivism. Consequently, it is rational to compare this year and last year's students' final examination results. One major change was for the teacher to change his role to more of a mentor, as compared to a classic teacher, who simply delivers knowledge.

4.4.1 Documents

To compare the final examination results of students in 2013 and 2014 we needed to collect the data from both groups of students. The final grades of students in 2012 and 2013 were saved in the lecturer's database, in order to analyze the results.

4.4.2 Questionnaires

This type of data collection technique is one of the most common techniques in social researches. In fact, we formulate our idea in the form of written questions for those who

have experienced or have opinion in special topic. We formulated our questions and passed them to respondents and asked them to fill out. We used online questionnaires for new 2013 students. We attached our surveys in the appendix section.

4.4.3 Observation

We performed observations and analyzed students' behavior in the system. We used structured observation to monitor classroom events. The group sessions were recorded and added to our database in a systematic way. Interactions between pupils and teacher via email, Skype chat or in the forums are a part of our observation and by getting memories and writing diaries; we added them to our database so we could record events in a systematic manner, code them in specified categories and analyze them with grounded theory.

4.4.4 Literature review

We have done a complete literature review and compare the different results, find problems and flaws or success factors which will be discussed in the following sections.

4.5 Quantitative and quantitative analysis

1. **Quantitative analysis**

Our data is presented in tables and documents. In the tables we use the Likert scale from 1 to 6 to show agreement and disagreement of students with the context of questions. We used the Likert scale to change the nature of the data (qualitative to quantitative) in order to obtain quantitative data.

2. **Qualitative Analysis**

The procedure of qualitative analysis based on grounded theory, is as follow in different levels:

1. Collection of data: collect new result after applying constructionism as a kernel theory;
2. Open coding: conceptualization of data;
3. Selective coding: finding core variables of data;
4. Memoing: keep track of idea, comparing concept of theory;
5. Sorting: formulating separated result of Memoing;

4.5.1 Terminology in Analysis Process

In our process of analysis, here are the meanings concerning our use of the following terminology:

1. Hypotheses: our proposed explanations concerning some phenomenon
2. Concepts: general or abstract idea about specific subject or issue
3. Explanation: statements which make something eligible
4. Understanding: our perception of the meaning of something, issue, or even research question
5. Analysis: is about search for explanation or understanding something in advanced

In our data analysis we want to investigate the following points and their relationships:

1. How many respondents answered given questions, in a certain way?
2. Is there some relationship between the students' answers and the students' performance?
3. Is there a relationship between the new 2013 course teaching methodology and an increased effective learning?
4. Is there a relationship between the new 2013 course teaching methodology and the students' survey responses?

4.5.2 Significance, Reliability, Generalizability and Validity

Researchers should be able to assess the following four concepts and to defend their own work. We assert that our research was based on ethical grounds and we are ready to defend our research via the following concepts:

Validity: does our method, approach and techniques relate to what we have been exploring?

Reliability: how well we carried out the research project? If another senior researcher looks through the same questions and data, will he come up which the same results?

Significance: the likelihood that results are coming from our sample could have been found by chance. So, more significance in the result, results in a more accurate of judgment that our results are genuine.

Generalizability: our research is interesting for other researchers if our research can be generalized to a wider scope of phenomenon. The relevance of different factors such as Luleå University, teacher and students should be clarified in the final result.

4.5.3 Linking Research Techniques, Approach and Family in our Research

These three concepts are the main dimensions of our research process. It is accepted that in the research process, some other alternatives such as new dimensions can be used, but each of these concepts should be in light of our research questions. We used complex, or grid tables, to classify the students' answers to the questions.

The following table is briefly showing research type, approach, techniques and analysis methods.

Research approach	Research technique	Data analysis
Action design research	Questionnaire, documents, observation, Literature review	Likert scale Grounded theory (coding)

Table 1 Methodology in brief

4.6 Record our Process

We have applied the constructivism beta model on students in the data communication with security course and asked students to fill in our questionnaires online. We saved our data into two different excel files. We also have access to the same data, via a MySQL database.

5 Constructionism learning theory as a learning approach

5.1 Constructivism / Constructionism as a kernel theory for IS design research

As it is explained before, IS design research such as ADR is a practical research process which should be done based on relevant kernel theories. Constructivism/constructionism is our kernel theory which fits to our research.

5.2 Motivations for the use of Constructivism

The Luleå University of Technology has already approved constructivism, as a form learning theory methodology, for the University courses. However after looking into constructivism, we concluded that constructivism is not being properly implemented, in many classes. Therefore this increased our motivation to use constructivism.

5.3 Definition and History of Constructivism and Constructionism

This chapter also includes the theoretical background and literature review of the thesis.

This chapter describes the definition and history of constructivism/constructionism during the last few decades and includes previous research which has drifted towards shifting from the instructional methodological approach of learning to constructional methodological approach of learning in both types of physical and virtual classes. This shift needs the concurrent orientations and innovations in pedagogical practices (Tenenbaum, G. 2001). Our theoretical background is simply that our research is specifically grounded in the following two different but related types of learning theory, constructivism and constructionism.

5.4 Constructivism learning theory as a learning approach

Choosing an appropriate pedagogical approach of learning to improve learning and increase satisfaction of students is significant. Constructivism is of the best alternatives among common approaches of learning to improve traditional way of teaching and learning by emphasizes on collaboration between educators, learner-based environment and encouragement of students' reflection through experimental learning (Crotty, T. 1997). Based on Ultnir, constructivism is an epistemology which includes a learning thorough

meaning-making theory and constructs a relation between human beings learning and nature of knowledge and most importantly, the teacher is assumed as a co-explorer who encourages pupils to rise up questions, challenges students' idea and formulates it to get the conclusion (Ültanır, E. 2012). The teacher must become more of a personal tutor, as opposed to delivering content to all students. Constructivism and constructionism are seen in many areas such as learning methods, social, engineering, medical area and applied science. So, it covers a wide area of knowledge and education.

Therefore, based on Verillon, Constructivism learning theory helps higher educational institutes reach their educational goals. Constructivism also improves the students' aptitude, related to advanced technology, and new curriculum. It provides a strong focus on school activities and industrial practices to help student become more familiar with industrial models. Thus, constructivism has considerable effects on educational theories and changes both sides of knowledge and cognitive structures (Vérillon, P. 2000). When the learner acts as an active agent in the learning process, it also increases retention, satisfaction, high level of thinking skills and positive attitude toward hands-on courses. Furthermore, learning is a social component which integrates with the environment and it is a self-regulated process which everybody learns due to his/her characteristics, situations, capacity and personal pace. Constructivism makes it possible to assimilate reality with an innovative idea and provides a situation for learner to learn out of existing knowledge by socio-collaboration interactions with web-based technologies (De Freitas, Sara 2010) and engages learners as part of learning process to construct learning process.

John Dewey, Piaget, Papert, Vygotsky and Bruner are famous founders of constructivism learning theory, who effected on learning theory in the last decades. They believe that Constructivism stimulates students' interest to learn independently and it is the main reason of the change in the role of students from passive learner to active learner.

In fact, each person has their own logic of thinking and integrity which is a result of current needs. As a result, making changes in the current state of individuals is not an easy task. However, conceptual changes appear when people's experiences occur (Ackermann, E.

2001). So, the most important principles of teaching in constructivism/constructionism theory of learning can be categorized in the following two main groups:

1. The teaching process should always be indirect and passive in the light of students' prior knowledge.

2. The new knowledge needs to be transformed as an input data because the knowledge is not raw information which can be delivered from one to another. Instead it would be an experience which delivers through interaction of people with each other and with environment.

CLM or constructive learning modern knowledge does not give students the real facts but only helps them to discover solutions, via their own exploration. It helps students to interpret and analyze problems and events of real world and thereby discover the trends of coping with problems (Yeager, R.E. 1991). Yeager believes that every single student should identify problems themself and try to be more innovative, suggesting solutions as an answer and having the ability of self-analyzing. In constructivism/constructionism learning theory, the teacher/mentor tries to make students more involved with facts and asks them to explore problems and motivates students to initiate ideas and encourages them to propose and predict new solutions. These processes must be done by every individual student, in order to give them adequate time to define their own analysis. This approach is generally applicable when this process goes through individualized instruction instead of pre-instructional design. Therefore, constructivism/constructionism theory is the combination of theoretical concept and operational practices.

Constructivism learning theory improves the involvement of participants, retention and depth of learning. Therefore, it is persuasive and reasonable fact to use this pedagogic approach for educator in respect to their needs as an active agent in learning process and provides educators to learn by doing in individual pathway of learning instead of prepared instructions by the teacher. So, constructivism considers students as independent individuals who construct knowledge through experiences and by combining those via cognitive

structure instead of simply receiving knowledge. Teachers cannot deny students' knowledge however, they must try to guide student to the correct theory of learning (Ben-Ari, M. 1998).

Another dimension of using constructivism learning theory is its combination with ICT to build a new way of education in distance by helping of computer. Computers are considered as a support tool, to make experimentations and active learning knowledge possible (Moreno, L. 2007). Therefore, it stimulates students to perform knowledge-searching scenes via ICT. It often shows that the learning is a kind of searching method for meaning through creation of experiences and helps students to have multiple perspectives of facts.

Three basic principles of constructivism learning theory based on Dalgarno are (Dalgarno, B. 2001):

1. Each person makes their own representation of knowledge (Dewey, Kant) that causes to make personal experiences and prior knowledge and from external world
2. The Process of learning occurs during the exploration time when the learner finds inconsistencies between current knowledge and prior knowledge (Piagot)
3. Learning occurs in the social interactions of learners and peers (Vygotsky)

Dalgarno insisted that one of the fundamental principles of constructivism learning theory is learning through the learner's activity instead of being passive receiver of information (Dalgarno, B. 1998). Furthermore, it is very common to hear about paradigm shift especially when these changes happen by higher speed due to the virtualization of knowledge in all fields of learning in order to bring new conceptualization, wider thinking and newer perspectives (Applefield, J.M. 2000).

Adoption of different learning theories is resulting in a controversial paradigm shift of human learning systems. For example, the pattern of completion of instructional approach of learning to constructionism/constructivism approach based on Cooper is his consideration happened in two phases: from behaviorism to cognitive and from cognitive to constructivism (Instruction, D. 1993). Mutation in different eras of applied constructivism shows a trend of evolution in a way that completes it in each era.

5.5 Constructivism vs. Objectivism Constructivism vs. Objectivism

One of the specifications of constructivism is its divergence from objectivism learning theory. In objectivism traditional learning theory, knowledge is independent from learner and it is transferred by an external reality to an internal reality of learner e.g. teacher is as transference of knowledge to students. Moreover, in the comparison of constructivism to other learning theories such as objectivism that only focuses on the learning content, constructivism is less content-oriented and more learner-centered. In constructivism school of thought, it is believed that conception of knowledge is derived from a meaning-making search when the learner is involved in the process of interoperation of experiences individually (Applefield, J.M. 2000). Consequently, constructivism is more epistemological and considers knowledge construction instead of transmission of information to the learner. So, it is critical for designers of constructivist framework to know how to motivate learners intrinsically and avoid of having ill-structured framework since intrinsic motivation can effect directly on exploratory behavior, Self-Regulation, capacity of exploration, and mastery by students (Ryan, R M. 2000).

5.6 Constructivism in distance learning

According to Gillet, a flexible pedagogy perspective is a learning perspective that students have freedom to organize autonomy, participation and collaboration in learning. In distance learning, we also have an ICT technological perspective that allows data communication through infrastructures but in a way that has less teaching instruction and more learning opportunity for students (Gillet, D. 2005). As Webb implies there are four different affordances from studies in ICT-rich environment that we can name as four main benefits of learning in ICT-rich environment; cognitive development, increase students' self-management, facilitating of data collection and provide students to gain experiences from real-world experiences (Webb, M.E. 2005).

Rob Martens, Theo Bastiaens, and Paul A. Kirschner believe that many e-learning courses are using tasks which follow constructivist design principles in virtual environments with authentic problems in ill-structured tasks, which motivates students to become part of a

learning process (Martens, R. 2007). According to Martens, it is difficult to choose which competence and learning skills are required to be put into the content of distance learning and this may cause confusion in the designing of learning theory. He believes that the combination of new educational pedagogy and new technology is not an easy task. It is so sophisticated to concentrate on both technology of knowledge delivery to student and systematic design of pedagogy approach equally. In the philosophy of constructivism approach in distance learning, it is hard to distinguish between instructional model and constructional model of learning process (Martens, R. 2007).

Jara, C.A.; Candelas, F.A.; Torres, F.; Dormido, S.; Esquembre ,F. considered virtual labs as an experimental setup to provide accessibility for distance students to have collaborative communications based on the constructivist method of transmitting knowledge and experience from teacher to students. This collaborative learning method encourages students to construct knowledge and deeper understanding. However, based on their point of view, although asynchronous interactions are more flexible in time, the downside is that students feel more isolated which reduces their motivation to learn. Consequently, they preferred synchronous interactions in which students can get teacher feedback immediately and where the students have direct supervision (Jara, C.A. 2012). In our study, we had the teacher focus on changing to the role as a mentor. The student feedback indicated that the teacher had achieved the goal as acting in the new role, as a mentor.

Based on Balta, collaborative learning and reliable tasks in distance learning can play an important role to impact the students' perception and motivation. Usually those distance courses which are based on constructivism learning theory motivate students to have better perceptions of the context of knowledge. One reason that there is a huge leap in the distribution of e-learning in many higher educations is because of considerable saving in time and costs. Therefore, the new learning systems for distance learning via the web became a revolution that caused conjunction of information technology and constructivism learning theory. The combination of both technology and constructivism is resulting in

personalization of the education which effects on learning in a positive way (Balta, O.C. 2009).

Sara de Freitas, Genaro Rebolledo-Mendez, Fotis Liarokapis,George Magoulas and Alexandra Poulovassilis proposed a four dimensional framework of educational methodology based on constructivism learning theory in distance learning. The framework includes 1) profiling the requirement of learners closely to their needs in achieving learning activities and pleasant results. Interaction between students via the virtual environment should be analyzed in systematic form. 2) Analysis of the pedagogy perspectives of learning which can have effects on training methodology, for example constructivism approach that involves learner as a vital part in the process of learning 3) representation of learners' experience in simulation environment, and 4) context of knowledge and related supporting resources in virtual environment (De Freitas, S. 2010).

Based on Mikropoulos, the two important indications of virtual environment are natural semantics and design features for the student-centered learning so he reached to the point that constructivism is a contemporary theoretical model which most of computer-based educational environments consider. Tassos A. Mikropoulos, Antonis Natsis achieved interesting result by reviewing outcomes of 53 articles in their Educational virtual environments paper: A ten-year review of empirical research (1999–2009): learning outcomes in 51 reviews out of 53 were positives (Hew, Khe Foon 2010; Mikropoulos, T A. 2011). As a result, positive outcomes affect directly on user performance and increase the level of knowledge of students. Mikropoulos implies that studying the main features of virtual environment, is an important step to understand the contribution of positive learning outcomes. He believed that hands-on laboratory exercises gives a sense of being in the physical campus and helps students to construct knowledge under social constructivist theory (Mikropoulos, T A. 2011).

5.7 Constructionism learning theory as a learning approach

To complete Piaget's learning theory, Seymour Papert developed a theory of learning based on Piaget's constructivism learning theory which tends to use media and context along

individual preferences and style to develop Piaget's model in 1960'ies. Papert's ideas helped researchers understand how ideas are transformed by expression through different media, by individual minds. So, in the constructionism school of thought, there are shifts from universals to individuals' objects-to-think with. In Papert's opinion the main emphasis is on the computer-based technologies and digital media as external aids for learner to express ideas. In the constructivist view, educators dynamically and actively construct new knowledge by interaction with the environment and other educators start a challenge between prior knowledge and new knowledge in the educator's mental world. So, for deeper understanding of this new knowledge, it is recommenced in constructivism to use new knowledge in wider environments successfully.

Based on Kafai and Cocciolo "constructionism brings to mind the metaphor of learning by constructing one's own knowledge, and is contrasted to the more traditional 'instructionism,' which favors the metaphor of learning by transmission of knowledge". Papert, the father of constructionism, considers an artifact as an object-to-think-with, with which the learner creates the tangible artifact and shares it with others. In fact, Papert believed that designed artifacts can be objects in the one's mind which moves from designer or learner. This can start a connection between the old and new knowledge, which results in the construction of the new knowledge and finally results in a tangible artifact, for others in a social environment.

The constructivist approach relies on creation of proper situations and opportunities for students, thus providing them with intellectual conflicts, based on their prior and past experiences. This is what pushes them to think about the source of debatable object. In between, students are provided with suggested activities which often help them to reconstruct their knowledge. These suggestions are aligned with real-world case study in order to create relevant problem-solving activities. Besides that, students should also interact and collaborate to share their ideas in a constructivist learning approach. PBL or problem-based learning is a method which has been used recently in constructionism and constructivism approach of learning. In fact, learners are asked to solve ill-structured,

authentic problems where students are in the center and the teacher acts as a facilitator to support students but not by direct answers. Discussions and collaborative work are those course components which improve the collaboration in PBL and constructionism. Constructionism seems to encompass a wide range of theoretical approaches to learning and suitable pedagogy for using in virtual worlds which have tools with flexibility of building and rebuilding objects in persistent environment (Girvan, Carina 2010).

5.8 Detailed Principles of Constructivism/Constructionism Learning Theory

The following is a summary of some important principles:

1. Consider each student individually based on his/her background which is student-centered approach to understand deeper;
2. Have a group discussion to share and create new ideas/collaborative learning and teaching;
3. Meaningful learning;
4. Special assessment of learning;
5. Construct specific strategies of knowledge discipline for each topic;
6. Give significance to learning the context as an alternative to the memorization (Moreno, L. 2007), so build knowledge, have group discussion and apply social construction;
7. Problem-based learning and case-based learning (Hanson, J.M. 2008):
8. Discovery learning;
9. Collaborative learning;

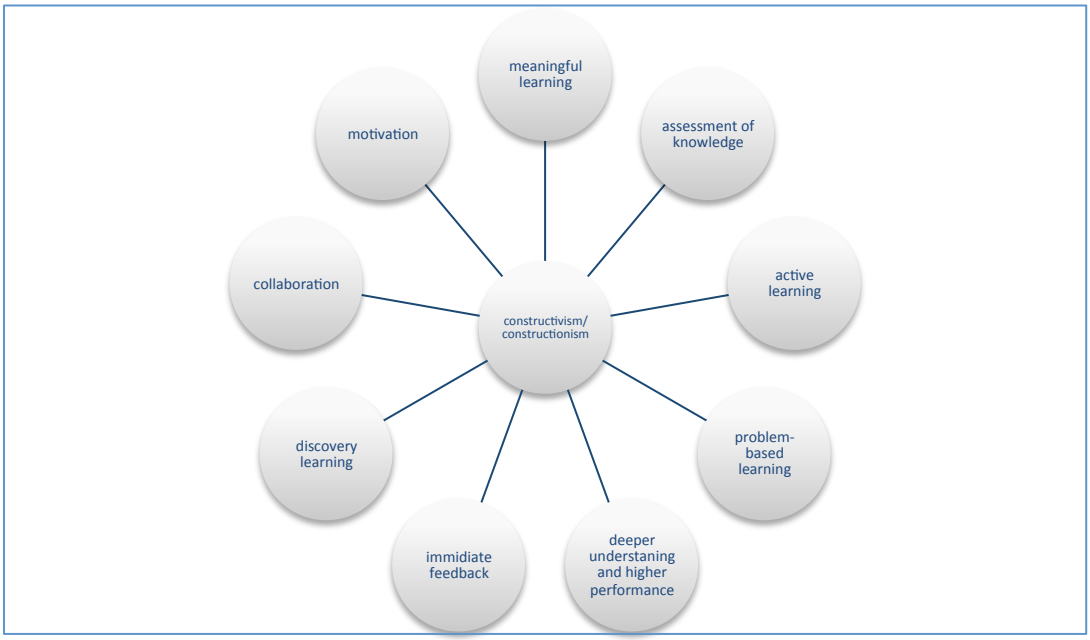


Figure 2 Principles of Constructivism/Constructionism Learning Theory

Principles of Constructivism/Constructionism Learning Theory

Principles of constructivism	Usage of constructivism in our thesis
• **active learning**	• Teacher motivates students to have Non-graded activities during session • Involve learner (students) as a vital part in the process of learning • Find requirement of learners closely to their needs in achieving learning activities and pleasant results
• **meaningful learning**	• Representation of learners' experience in simulation environment • Design to use CompTIA Network+N10-

	005 Simulator which help students to find a relation between real work in practice and what they learned through classes
• **motivation**	• We use the teacher in his teacher role to motivate students and to follow new knowledge, this technic was introduced by teacher Todd Booth.
• **Collaboration**	• Students have group discussion in class or share their ideas via Emails and live chats or in forums
• **discovery learning**	• After the introduction of new topics and students are well motivated, they have to start searching and finding new knowledge. It could be done by searching through internet or group discussion that help students to learn new things from these activities
• **deeper understanding and higher performance**	• Students must Do hands-on exercises via the use of the simulator after each session • Students are asked to design exercise for each other • Students have to write reports after each session or give brief of session

• **immidiate feedback**	• Students have the opportunity of sharing their ideas and obtaining immediate feedback by the teacher simultaneously
• **assessment of knowledge**	• Students will be evaluated with hands-on exercises ruing the exam • Students have to take a Post-test After each session, it could be a random question or quick test
• **problem-based learning**	• To motivate students, teacher will introduce interesting but ill-structured or problem based related topic to motivate students to dig and concentrate on new topic

- **active learning**

We try to avoid the passive role of students based on Rovai that may cause some other issues such as time limitation, lack of clear feedback from instructors, limited accessibility to materials and to teachers, feeling of isolation can effect negatively on students' perception and cause frustrations and anxiety and finally dissatisfaction in students (Rovai, A.P. 2004).

Also, we followed Dalnarna, (Dalgarno, B. 2010) paper that, one of the most important benefits of virtual environments is simulation of the real world for learners and interaction of learners with objects in a virtual learning environment.

To use active learning as one of the constructivism principles, we used the teacher in two different roles in the e-learning process. Firstly, we used the teacher in his instructor role and second, the teacher acted as a supervisor or coach.

Students faced ill-structured problem from teacher in order to discover new knowledge; this is how we used the student's activity to reach to the active learning as one principles of constructivism.

- **meaningful learning**

Without practical real-world hands-on experience, in security, InfoSec students are unable to integrate knowledge material and technology (Yang, T.A. 2004).

Based on Ultnir, constructivism is an epistemology, which includes a learning thorough meaning-making theory and constructs a relation between human beings learning and nature of knowledge and most importantly, the teacher is assumed as a co-explorer who encourages pupils to rise up questions, challenges students' idea and formulates it to get the conclusion (Ültanır, E. 2012).

To reach the required meaningful learning as one principles of constructivism, we used the CompTIA Network+N10-005 Simulator to conduct students to make rational relation between theoretical knowledge and reality in practice.

- **assessment of knowledge**

We try to educate in such a way that we obtain a quick assessment of the student's learning in each session by choosing students randomly and ask them to summarize the session or take a post tests.

- **problem-based learning**

Yeager believes that every single student should identify problems themselves and try to be more innovative, suggesting solutions as an answer and having the ability of self-analyzing. In constructivism/constructionism learning theory, the teacher/mentor tries to make students more involved with facts and asks them to explore problems and motivates students to initiate ideas and encourages them to propose and predict new solutions (Yeager, R.E. 1991).

- **deeper understanding and higher performance**

Constructivism considers students as independent individuals who construct knowledge through experiences and by combining those via cognitive structure instead of simply receiving knowledge. Teachers cannot deny students' knowledge however, they must try to guide student to the correct theory of learning (Ben-Ari, M. 1998).

Efficiency in e-learning can be expressed by knowledge building or by construction of new knowledge which concludes with authentic problems, self-organization, monitoring, creation of artifacts to collect knowledge (Girvan, Carina 2010).

Jara, C.A.; Candelas, F.A.; Torres, F.; Dormido, S.; Esquembre ,F. considered virtual labs as an experimental setup to provide accessibility for distance students to have collaborative communications based on the constructivist method of transmitting knowledge and experience from teacher to students. This collaborative learning method encourages students to construct knowledge and deeper understanding. However, based on their point of view, although asynchronous interactions are more flexible in time, the downside is that students feel more isolated which reduces their motivation to learn. Consequently, they preferred synchronous interactions in which students can get teacher feedback immediately and where the students have direct supervision (Jara, C.A. 2012). In our study, we had the teacher focus on changing to the role as a mentor. The student feedback indicated that the teacher had achieved the goal as acting in the new role, as a mentor.

Mikropoulos implies that studying the main features of virtual environment is an important step to understand the contribution of positive learning outcomes. He believed that hands-on laboratory exercises gives a sense of being in the physical campus and helps students to construct knowledge under social constructivist theory (Mikropoulos, T A. 2011).

Rob Martens, Theo Bastiaens, and Paul A. Kirschner believe that many e-learning courses are using tasks, which follow constructivist design principles in virtual environments with authentic problems in ill-structured tasks, which motivates students to become part of a learning process (Martens, R. 2007).

- **Immediate feedback**

We use the teacher in his instructor role to give immediate feedback such as ask questions, quick quizzes and some assignments. This is how we reach to the immediate feedback as one of constructivism principles.

- **Discovery Learning**

Constructivism makes it possible to assimilate reality with an innovative idea and provides a situation for learner to learn out of existing knowledge by socio-collaboration interactions with web-based technologies (De Freitas, Sara 2010) and engages learners as part of learning process to construct learning process.

CLM or constructive learning modern knowledge does not give students the real facts but only helps them to discover solutions, via their own exploration. It helps students to interpret and analyze

problems and events of real world and thereby discovers the trends of coping with problems (Yeager, R.E. 1991).

The Process of learning occurs during the exploration time when the learner finds inconsistencies between current knowledge and prior knowledge (Piagot)

- **Collaboration**

Try to involve the learner to construct their knowledge and then connect it to the prior knowledge. Have a group discussion to share and create new ideas/collaborative learning and teaching (Cocciolo, A. 2011). Also, we found out that Learning occurs in the social interactions of learners and peers (Vygotsky). Moreover in Moreno's paper, they give significance to learning the context as an alternative to the memorization (Moreno, L. 2007), so build knowledge, have group discussion and apply social construction.

In summary, it is emphasized in the constructionism process that learners should construct sharable artifacts (Girvan, C. 2013). Constructivism is of the best alternatives among common approaches of learning to improve traditional way of teaching and learning by emphasizes on collaboration between educators, learner-based environment and encouragement of students' reflection through experimental learning (Crotty, T. 1997).

Jara, C.A.; Candelas, F.A.; Torres, F.; Dormido, S.; Esquembre ,F. considered virtual labs as an experimental setup to provide accessibility for distance students to have collaborative communications based on the constructivist method of transmitting knowledge and experience from teacher to students. This collaborative learning method encourages students to construct knowledge and deeper understanding. However, based on their point of view, although asynchronous interactions are more flexible in time, the downside is that students feel more isolated which reduces their motivation to learn. Consequently, they preferred synchronous interactions in which students can get teacher feedback immediately and where the students have direct supervision (Jara, C.A. 2012). In our study, we had the teacher focus on changing to the role as a mentor. The student feedback indicated that the teacher had achieved the goal as acting in the new role, as a mentor.

In constructivism school of thought, it is believed that conception of knowledge is derived from a meaning-making search when the learner is involved in the process of interoperation of experiences individually (Applefield, J.M. 2000)

To reach to the collaboration as one principles of constructivism we used the teacher in his mentor role to motivate and conduct group discussion and encourage students to take participate to group activity and share their ideas.

- **Motivation**

We used the teacher in his instructor role to follow active learning as a principles of constructivism, to motivate and stimulate students based on (Rovai) and (KeenGwe, J. 2009). Based on Balta, collaborative learning and reliable tasks in distance learning can play an important role to impact the students' perception and motivation. Also, we found that Based on Kafai and Cocciolo "constructionism brings to mind the metaphor of learning by constructing one's own knowledge, and is contrasted to the more traditional 'instructionism,' which favors the metaphor of learning by transmission of knowledge". Papert believed that designed artifacts could be objects in the one's mind, which moves from designer or learner. This can start a connection between the old and new knowledge, which results in the construction of the new knowledge and finally results in a tangible artifact, for others in a social environment.

It is critical for designers of constructivist framework to know how to motivate learners intrinsically and avoid of having ill-structured framework since intrinsic motivation can effect directly on exploratory behavior, Self-Regulation, capacity of exploration, and mastery by students (Ryan, R M. 2000).

Discussion as to how our design principles relate back to the first page, with regard to ADR:

As has been made clear, we are applying the constructivism and constructionist design principles, via the application of ADR. Here we discuss how our design principles relate back to the start of this thesis, with regard to ADR.

5.9 Differences between constructivism and constructionism

Perhaps the main difference between constructionism and constructivism is the focus of constructionism on the social nature of learning and its social dimensional whereas constructivism isolates learner to construct his knowledge and then connect it to the prior

knowledge (Cocciolo, A. 2011). Constructionism argues the roles of constructing experiences personally with highly and actively possible of texting, exploring and extension of knowledge. Immersion in knowledge, collaborative learning, embodied social presence and flexibility are features of constructionism which in this master thesis we will focus on.

Totally, emphasizes in the constructionism process is constructing sharable artifacts (Girvan, C. 2013). What constructionism is really focusing is mainly on providing learners with some tools to construct objects in the real or virtual world, in order to facilitate constructionist learning experiences. In constructionism, the process of teaching is defined by strategies and style of instructions for the teacher because of the adaptable roll of the teacher in different phases of constructionism.

6 Action design research

Based on Sein, “ADR is a research method to generate perspective design through building and evaluation of IT artifacts in organizational settings (Sein, M. 2011)”. We use the ADR approach to reflect upon our fundamental assumptions and our hypothesis which caused many factors to emerge during development and use of our IT artifact. Based on reviewing research papers, it appears that ADR is not yet a very popular research approach. We also noticed that in WikiPedia, there is not yet even an entry for ADR. In fact, via WikiPedia, we found an entry for DR (Design Research). However, even within WikiPedia DR, there is absolutely no mention of ADR. We also read, which is perhaps the most popular book, specifically written to educate students who are writing a thesis, which is originally written by Kate L. Turabian (titled, “A Manual for Writers”). Even in this book there is absolutely no mention of ADR. Therefore, we decided that there is no reason to strictly limit our methodology to ADR. Therefore, the reader may find some aspect of our paper, outside the scope of ADR. Our opinion is that it is clear that there is no reason not to use a blended approach (more than one methodology), which such an approach can always be superior to a tunnel vision, I.E., single methodology approach.

As explained in our paper some surprises came up. In addition to the surprises documented in our paper, the following surprise came up. Our assertion was that an active learning approach with hands-on labs should be used. In our initial research, we didn’t know exactly how much time was required, in order to have the teacher create, maintain, grade, etc…, all of the course hands-on labs. Late in our research, we looked into this issue. The teacher Todd, who has two industry certificates in security (from CompTia and Cisco), did a very careful analysis, as to how much time it would take to master and create the hands-on security labs. The result was that it took Todd about 100 hours to master the required security aspects. Todd was required to master the material before he should create the hands-on labs. It also takes time to grade all the hands-on labs. One issue is that the other teachers in Todd’s department do not have the security technology background, which Todd has. So it might take them twice as long, 200 hours to master the required security aspects.

In the teacher Todd's department, as is perhaps common, the teachers are not allocated any extra hours to create hands-on labs, unless the course is being taught for the first time. So we need to take this "investment" into account, before making a recommendation, as to if hands-on labs. So the issue we ran into was the following. It is not fair to recommend that teachers create hands-on labs, unless we also take into account that it may take 100-200 hours to create these labs. To put this another way, if teachers are not allocated any extra hours, does it make sense for teachers to use 100-200 of their otherwise allocated hours to create hands-on labs. Given this question, in general, the answer is no. We still recommend that active hands-on labs would be beneficial. However from a practical point of view, we need to find a way to reuse existing hands-on labs, so that teachers will not need to create these hands-on labs, on their own. We were able to find pre-existing hands-on labs. However since this was not the focus of this paper, we did not pursue this area. To extent that our paper is considered purely academic research, perhaps this issue that it take 100-200 hours to gain the knowledge to prepare the hands-on labs is not as much of an issue.

The above issues is what can be considered that did not work out. Another issue we ran into was the following. Using a strictly ADR approach, it is the IT-Artifact which takes the center stage. However in this respect perhaps we can say that ADR is someone in conflict with constructivism and constructionism. I.E., via constructivism and constructionism it is also the approach which is relevant. For example, one design principle is for the teacher to act as the mentor. However, in constructivism and constructionism there is no requirement for the teacher to act as the mentor, via the implementation of some specific IT-Artifact. This provides additional grounds as to why there is no reason, and there is a reason not to, use ADR as a strict one and only approach during the thesis process.

Related to ADR, there is the question as to which results we achieved. Our results, which are partially based on ADR, are found in our 11. Results and 12. Discussion chapters.

ADR is related to DR (Design Research). ADR has the goal of improving the relevance of research by performing research in cooperation with practitioners. ADR is used to make a judgment in concrete situation and evaluation of "theories" or "hypothesis". In ADR,

theories are not evaluated separately and individually hence they evaluated through iterative processes. Based on our literature review, ADR is famous between small-scale researchers in the social science, particularly in education, health and social care. Our research in the field of effectiveness in education, and therefore ADR is a good fit for our research.

In this chapter we will describe and articulate how we used ADR. We did obtain positive feedback via the constructivism surveys. For example, we obtained good results that teacher Todd was acting in the new role as a mentor. Via the ADR iterative process, we would able to continually improve the mentor feedback, during each ADR repetition.

According to Sein, there are four explicit stages which create the structure of ADR in one research (Sein, M., 2011). The following diagram is extracted from Sein's paper "**ACTION DESIGN RESEARCH**" in 2011.

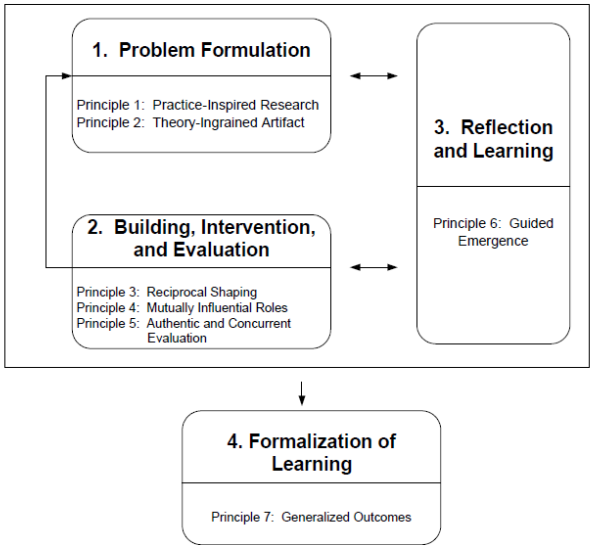


Figure 3 ADR stages based on Sein

Sein believes that the ADR method conceptualizes the research process and inherently interwoven activities of building the IT artifact and intervene those activities in the organization, and simultaneously evaluates it (Sein, M. 2011). So, ADR generates theory with researcher's intervention to solve immediate organizational problems, obtain feedback and

finally to analyze new emerged factors in the process, in order to achieve an improved situation. These iterative processes are based on cycles of inquiry. In another word, ADR is a two phased process: Firstly, design an IT artifact and then implement and evaluate it through action research.

6.1 Criteria of ADR

1. Educative;
2. Deals with individual or a social group;
3. Contains of cyclic process in those researches which evaluation and actions are interlinked;
4. Contains change innervation;
5. Has goal to improve a raw artifact:
6. Focused on special context, problem;

6.2 Why use ADR to Produce an E-learning Model in the Data Communication with Security Course?

ADR is a handy tool for us to generate our perspectives about designing knowledge for producing *an e-learning model* of the data communication with security course and to open an innovative way to increase throughput performance of students and learning effectiveness. One contribution of this model is to have virtual labs and hands-on exercises. This will require students to be more active, which is a main goal of the constructivism learning theory. Since we are building and evaluating this model of e-learning as an IT artifact in the *data communication with security course,* ADR helps us to address the problem of limited active learning in order to increase the effectiveness of learning in data communication with security course and via the use hands-on exercises in virtual environment based on a systematic approach of teaching and learning.

Consequently, the ADR approach allows us to apply our model iteratively and get feedback in each iteration phase. So, we can be as a part of research and directly observe the changes

in students when we use this model. We obtained feedback via the observation of students' behavior and appearance of new factors as emergences improved the model.

Another reason that we chose ADR as our approach was because of its linked research process to the main context in the research, which leads to a practical purpose in a change view and processes spiral activities through repeated cycles and change it in every cycle. This constant feedback look has helped us ensure that our research is a relevant solution to the research problem at hand. Besides that, we applied our e-learning model after group sessions and based on students' behavior we obtained results and there were new factors which emerged in our model. These emerging factors can have an effect on our artifact directly or indirectly so, we have possibility of changing our artifact based on them.

Our approach to using ADR will now be presented. Normally, the ADR approach should be used with several iterative cycles. However, we used ADR for the first time in our thesis. It was not until the thesis course was completed before we learned, documented and received feedback on our use of the ADR methodology. If we had used ADR, after this course was over, we would be in a better position to use the iteration cycles of ADR. There was another issue. We were only able to use ADR for a single course which is only taught once per year. If the same course had been repeatedly taught each term, we would have been able to use ADR, to improve the second iterative of the course. However this was not the case. Therefore, due to the limited course schedule, we were limited in our ability to perform the ADR iterative cycle approach.

7 Stage 1: Problem Formulation in ADR

In the first stage, the problem is perceived by practitioners and end-users. We have used different resources and approaches to formulize problem. Firstly, we had an interview with Todd Booth as a teacher of data communication and security course in 2012 and 2013 and use his experiences as teacher of this course to find out the problems that he faced during lectures. Secondly, we have done a very complete literature review to review past similar projects. Finally, we combine both Todd's experience with similar problems to formulate problems.

Todd Booth who is responsible of data communication and security course believed that students who would become Information Security engineer should have access to virtual environment and hands-on exercises. Besides that, this course should be provided along active learning where students can learn through construction of knowledge. We identify and conceptualize a research opportunity based on existing theories and related work by doing a structured literature review to find out about what we know about the data communication with security course structure. We must also determine our final goal based on our assumptions and hypotheses, related works and finding the gap between current knowledge in our research question area and our goal. What we would suggest, is an e-learning model for data communication course based on Constructivism learning theory in which traditional role of teacher as a main agent of learning process shifts to mentor agent and provoke self-motivation in students, by moving from instructional learning paradigm to constructional learning paradigm. One solution is designing and implementation of a virtual environment for students which we would call it as "Virtual Campus" and apply a push from teacher's side to maximize experimental effect in students (Shuang Wang 2012).

7.1 Tasks taken in the problem formulation stage

1. Define and Conceptualize the Research Opportunity

Improvement of the data communication with security course and increased effectiveness in learning by proposing an e-learning model as an artifact based on constructivism learning theory via active learning.

2. Formulate initial research questions

- How can we implement Information Security course based on constructivism principles on e-learning course of Information Security?

- Does the production of the new e-learning model based on constructivism help to increase learning effectiveness and performance for data communication with security course?
- Can we expand our model to other technical courses of MCs the Info Sec at LTU?

3. Cast a problem as a class of problems

It is not only data communication with security course which needs to have a virtual environment for students to construct technical knowledge and learn though doing hands-on laboratories, also there are some other technical courses at this master program. Besides that, there should be a systematic approach of learning for distance students to engage them actively in learning process. So, the result may be useful to generalize for other similar technical courses

4. Define contributing theoretical bases and prior technology

Based on designing a new theory of Gregor, we design a new theory of e-learning model based on constructivism for data communication and security course.

5. Long term organizational commitment

Consider benefits of LTU and students based on LTU's vision and mission

6. Define roles and responsibilities

Researchers (Mina and Todd) try to formulate problems and propose solutions based on their evaluation, to practitioner. The practitioner, (Todd) then must implement the proposed new e-learning model and students should act to the new system in their new roles

We had a semi-structured interview with Todd Booth, the Teacher of the Year 2011 and research engineer at the department of computer science, electrical and space engineering and has taught many information security courses. Based on Booth, here is a diagram of ordinary sessions of data communication and security course in one LP:

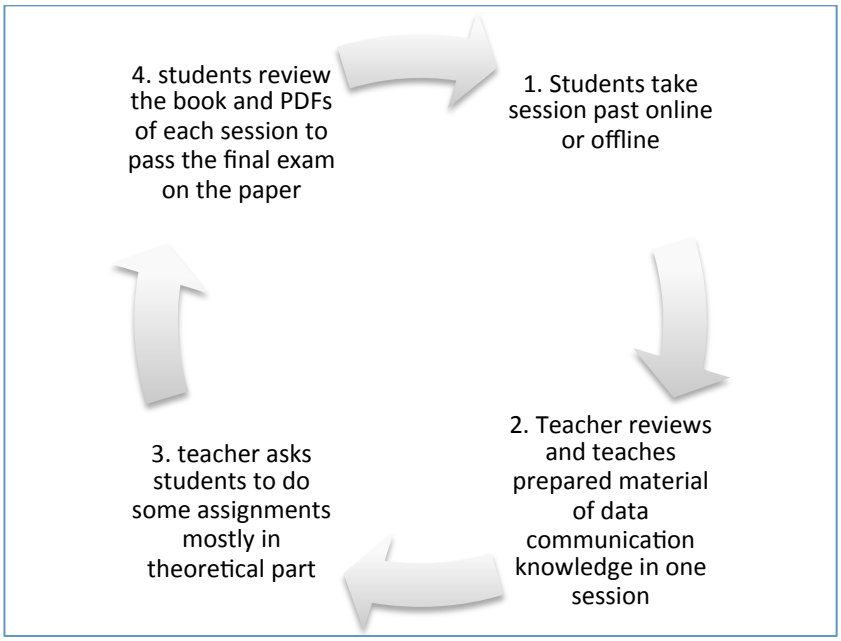


Figure 4 an ordinary data communication and security course during one LP

LTU has informed the MSc Information Security Program students, via the official handbook, that LTU will prepare students to become employed as InfoSec managers and as InfoSec engineers

Also, we had some group discussions, participant's observations, technology review and semi-structured interview with students to find the reasons of some dissatisfaction between students.

7.2 Final Problem formulation

The following was inspired and/or motivated by an existing problem and/or limitation at LTU. The proposed solution was inspired by constructivism and constructionism.

LTU's current lab status is inadequate and incomplete to prepare LTU students to become InfoSec engineers. So LTU should provide virtual laboratories in order to provide hands-on exercises. Also, to increase effectiveness in learning, students must be more active in the learning process. Constructivism learning pedagogy supports students to be active in learning process. Also, the current online class does not properly support active learning since no students are required to attend any group sessions. A summary of the current problems are listed below:

problem	Current approach of teaching for data communication course
1. Lack of required technical skills for students to become employed as InfoSec engineers	The current content of material and course syllabus for this course without any practical assignments is not well enough to make students eligible to become InfoSec engineers
2. LTU's virtual lab infrastructure is inadequate for distance students of data communication and security course to have access to hands-on exercises by connecting to the virtual lab	LTU's current lab status is inadequate to prepare students to become InfoSec engineers
3. Data communication with security	Data communication with security is taught

course should be taught in more active learning manner and LTU needs to make the students more active and motivated, by including lab activities in each session	in a way that teacher's role is more emphasized and students are silent receiver of knowledge and students don't exercise practically. Besides that, students are allowed to take the course synchronously or asynchronously. I.E., students are not required to attend any group sessions.
4. Data communication with security course needs to be taught based on more systematic pedagogy of learning	Data communication with security is taught based on traditional classroom disciple and this might be a reason of not having inactivity in students role in learning process
5. Data communication and security course final examination is taken from theoretical concepts	Students take ordinary exam in distance or on campus and content of exams are mostly coming from theoretical part of data communication and security course. There were no hands-on labs required during the examination.

Table 2 Problem description and current situation

Stakeholders in our research:

As we are working for practitioners at the Luleå University of technology, students of MSc Information Security program, and the Head of information Security division are our stake holders. The Swedish Department of Defense provided us with an external supervisor. The Defense is also interested to collaborate, concerning the findings in this thesis.

Principle 1: Practice-Inspired Research. Try to express field of problems in order to get closer to the knowledge creation and use ADR to find dynamic opportunities in the scope of work, technology and current theories. We want to generate knowledge in order to improve

the data communication with security course. The solution and result may be generalized and applied to a wider class of problems, and related to other similar courses in the Information Security program education which would benefit from hands-on lab by systematic teaching approach. So, the starting point of research was motivated by the perceived ability of improvement in the teaching approach of the data communication with security course.

Principle 2: Theory-Ingrained Artifact. It is important to explicitly state that our e-learning model to improve student learning is based on constructivism learning theory and it is based on Gregor's paper that makes systems of statement of abstractions to be a theory. However, the current theory of teaching the data communication with security course has been based on the teacher's role, in which the teacher is the most active agent in the classroom. In this role, the teacher tries to transfer knowledge directly to the students in a traditional way. The following table expresses principles in this stage briefly.

Stage 1: Problem Formulation		
Principle 1: Practice-Inspired Research	start point of research motivated by the need of hands-on exercises in the syllables of data communication course to fulfill students' requirement to become security engineer	**Recognition:** lack of adequate lab instruments to do hand-on exercises and a systematic pedagogical approach for data communication course to have active learning and learning through knowledge construction and make students more involved and active in the learning process
Principle 2: Theory-Ingrained Artifact	The current used theory of teaching approach for data communication and security course is based on teacher' role and students is passive receiver and in active in learning process.	

Table 3 Summary of Stage 1- Problem Formulation

By defining key concepts, problem framework and other interfered factors in stage 1, we can create a platform to design an e-learning model for data communication and security course. We have done a wide literature review through Action Design Research to reach the new framework of designing a new e-learning model based on the main design principles of constructivism. We have put it under test through an iterative process and evaluated after each circulation. Thus, we have monitored the students' behavior and feedback which then had an effect on the next iteration. Our design principles are a refinement of some constructivism principles, and our principles are focused on our specific domain specific problem.

7.3 Literature Review

Literature review is a very sensitive section and essential feature of any academic research. A strong literature review defines concepts and shows the knowledge gap between current knowledge and what researcher wants to contribute to the current knowledge. What researchers must do is to make an improvement in current knowledge as a foundation of advancement in new knowledge. The purpose of our literature review can be divided as following points:

1. Define critical concepts
2. What we know about the current knowledge
3. What are we looking for?
4. What is our goal?
5. Find knowledge gap in current academic literature
6. try to attack or criticize on deficient sides of current researches
7. find rational relation between research question and available literatures

7.4 IS/IT Journals Referenced in the Literature Review

The following table is a list of very popular and relevant IS/IT journals which are in the same field as our thesis. We were able to find and use references from each and every one of the following (between the period of October 2012, and February 2013):

IT/IS outlets
11th International Conference Virtual University,
IEEE
Digital Library and Archives of the Virginia Tech University Libraries
International Conference on Systems and Informatics
Aalto University
ACM Computing Surveys
ALT-J, Routledge
Am.Psychol., American Psychological Association (PsycARTICLES), [Washington, D.C.]
Blended Learning: Design and Implementation
British Journal of Educational Technology
Campus-Wide Information Systems
CBE Life Sciences Education
Communications in Computer and Information Science
Computer Applications in Engineering Education
Computers and Education
Computers education
Constructivist theory unites distance learning and teacher education
Distance Education
Education, IEEE Transactions

Educational Technology
e-Science - Second IEEE International Conference on e-Science and Grid Computing
Evidence Based Library and Information Practice
Expert Syst.Appl.
Future of learning group publication
Higher Education Research & Development
IEEE Transactions on Education
International Journal of Educational Development
International Journal of Instruction
International Journal of Online Engineering
International Journal of Science Education
International Journal of Social and Humanistic Computing
International review of research in open and distance learning
Journal of Computing Sciences in Colleges, Consortium for Computing Sciences in Colleges
Learning and Instruction
Lecture Notes in Computer Science
Planning for Progress, Partnership and Profit
Procedia Computer Science
Science Teacher, ERIC
Systems and Informatics (ICSAI), International Conference
Technology, Pedagogy and Education
The High School Journal
The Internet and Higher Education
The Journal of continuing higher education
Wireless Networks, Information Processing and Systems
World Academy of Science, Engineering and Technology

Table 4 Referenced IS/IT journals

7.5 Sources, data bases and filtering process of literatures

Luleå University of technology provides different databases for students like Scopus, Google Scholar, Proquest, Web of Science and ext. We used some keywords in the available databases to find related work. The following table is the summary of our keyword search. The process of filtering of papers in our literature review was the following:

1. search “constructivism” to find all those papers related to constructivism learning theory
2. use "constructivism" " learning" keywords to filter those researches which uses constructivist learning theory as their educational pedagogy
3. we use "constructivism" "distance learning" to find related researches which uses constructivist learning theory in distance learning
4. and continue to narrow down the keywords more precisely to desirable topic
5. read and analyze the abstract and result of papers
6. check out their references and citations

The following results were obtained during the time period of x and y:

Found papers	**Number of Document results**
"constructivism"	3,689
"constructivism" " learning"	1,483
"constructivism" "distance learning"	30
"constructivism" " higher education"	118
"constructivism" " higher education" "distance learning"	3

"constructivism" " higher education" "distance learning" "information security" ”active learning”	0
"constructivism" " higher education" "distance learning" "Moodle"	0
"constructivist learning theory" "distance learning"	6
"Moodle" " Social Constructionism"	1
“constructionist pedagogical approach” ” digital archives education”	1
"constructionism via constructivism" "Moodle"	0
"pedagogical approach” ”distance learning"	19
"virtual lab" "information security"	4

Table 5 Filtering keywords

7.6 Related Works

Based on our review, there are different papers which focus on the implementation of constructivism/ constructionism learning theory along with ICT. We found different related researches which applied constructivism as a systematic learning theory for distance education. We then divided them based on their failures and success into three main groups:

1. Researchers and practitioners who focused only on implementation of ICT and virtual laboratories without an explicit and systematic pedagogical approach
2. Researchers and practitioners who have focused on implementation of constructivism and its combination via ICT but still have passive role of students and active role teacher in center of learning process. They failed because they did not follow the exact principles of constructivism/constructionism
3. Researchers who applied constructivism successfully but who had some weaknesses with regard to active learning.

7.6.1 Projects with an effort on ICT and virtual laboratories labs without an explicit pedagogical approach

Zackrisson and Svahnberg (Zackrisson, J. 2008), Fuh-Gwo Chen, Ruey-Maw Chen, and Jr-Shian (Chen, F.-G. 2011) tried to have hands-on laboratories in a virtual environment. They understood that there is a need of having hands-on labs and designing virtual laboratory for some computer science courses. Usually, these researchers focused highly on technical aspects of having virtual laboratories in distance learning and didn't have explicit learning theory as their kernel theory such as constructivism or constructionism. Thus, the teacher has his/her traditional role in the center and students were passive agents.

For example, Zackrisson and Svahnberg in Blekinge Institute of Technology School designed an isolation virtual environment for students who need to connect remotely to do experiments. In their implementation, they considered security and technical aspects in top level and to shift towards technology of ICT in learning and there was no sign of reconstruction of pedagogy along with technology (Zackrisson, J. 2008).

Another example of a projects failure is the Fuh-Gwo Chen project, where he applied hands-on exercises through virtual labs for distance students in order to cut the infrastructure and maintenance costs. They had less attention to change curriculum of information security courses based specific pedagogical approach of education (Chen, F.-G. 2011).

7.6.2 Projects having constructivism as their kernel theory but who did not apply all of the dimensions of constructivism/constructionism (passive role of students, Active role of teacher)

Tenenbaum (Tenenbaum, G. 2001), Marten (Martens, R. 2007), Anisetti (Anisetti, M. 2007), James M. Hanson & Kenneth E. (Hanson 2008) and Stepan Hubalovsky (Hubalovsky, S. 2011) are categorized in this group.

Tenenbaum (Tenenbaum, G. 2001), Marten (Martens, R. 2007) found that the implementation of every principle of constructivism especially in related to ICT is not an easy task. The main reason of failure in Tenenbaum's project in 2001 (at an Australian university)

in applying constructivism as a kernel theory was due to the wrong implementation of all dimensions and principles of constructivism learning theory, and its application in higher and distance educations. The lack of social interactions between students and teachers, lack of real-world scenarios to practice with, insufficient instructions of teaching in flexible environment, ignorance of students' need, and lack of students' autonomy to learn through meaning process were the main reasons of their failure. In 2007 when Marten tried to develop constructivist approach at Open University of the Netherlands (OUNL), he didn't pay attention to the evaluation of learning approach and students didn't behave as he expected. His main focus was on possibilities and technology delivery and less on systematic design and evaluation of learning approach.

Also, Stepan Hubalovsky focused on the solution for distance learning programming course and related practical problems of object-oriented programming at university of Hrade Kralove. Based on his final result, educational methodology for practices was not well implemented due to the lack of constructivism learning theory for distance students (Hubalovsky, S. 2011).

Anisetti in 2007(Anisetti, M. 2007), applied constructivism as their kernel learning theory but the main principles of constructivism were not applied. They didn't consider active learning by making students more active in the learning process. So, teachers stayed in the center of learning process actively and students were passive receiver of knowledge. For example, Anisetti in the OVL project of Information Systems and Network Security of the University of Milan made more progress in designing and implementation of combination of constructivism based on systematic learning theory and usage of information technology in web based. His main focus on technical tools of implementation of virtual environment resulted in lack of students' autonomy to learn through meaning.

James M. Hanson a. & Kenneth E. Sinclair used social constructivism teaching method in Australian universities to increase professional skills. Their approach was based on the fundamental framework of social constructivism learning theory and received salient results

in two efforts. Hanson described constructivism as an approach that helps students to construct knowledge proactively by engaging them in the realistic problems. He emphasized that construction of knowledge helps student to understand and make connections between theoretical concepts and practical exercises so develop their skills professionally. However, the teacher role and student role are not very clear in their approach (Hanson 2008).

7.6.3 Projects with constructivism as their kernel theory and having success

Step by step, researchers have conquered and been successful in applying the principles of constructivism and its combination with ICT. We would like to call them as an improvement in implementation of constructivism in the literature review part. Shakeel A. Khoja, Faisal Sana, Abid Karim, Arif Ali Rehman (Khoja, S.A. et al. 2009), Peter Armbruster, Maya Patel, Erika Johnson, and Martha(Armbruster, P. et al.2009), Jing Ma and Jeffrey V. were (Ma, J. 2006), Yang (Yang, Z. 2007), Fernando Alonso, Daniel Manrique, José M. Viñes(Alonso, Fernando 2009), Gillet (Gillet, D. 2005) are categorized in those researches who helped to improve the combination of constructivism learning theory by ICT and help other practitioners to use from their results and experiences.

For example, Yang in 2007 implemented web-based virtual online classroom based on constructivism and objectivism. Even they got negative and positive feedbacks but students were satisfied. These researches were useful to use for future work (Yang, Z. 2007).

In the same way, Jing Ma and Jeffrey V. Nickerson in 2006 discussed simulation of remote laboratories. Even though, they didn't clearly define constructivism learning theory as their kernel theory of learning in their distance learning but the result included new aspects of having virtualization via a systematic learning theory:

1. Increase social skills of students of InfoSec by working through groups to perform engineering activities to push students to interact with each other to solve a problem

2. Professional skills that help students to become more technical or managerial solver

3. Design skills that provoke students to have more scientific mind and try to solve open-ended problems and construct innovative artifacts

4. Conceptual understanding that helps students to use concepts taught in the classroom (Ma, J. 2006)

Based on Shakeel A. Khoja, Faisal Sana, Abid Karim, Arif Ali Rehman, constructivist proposes is Construction of knowledge of educator's observation from events and combination of it in the past experiences. They provided a framework based on constructivism learning theory to organize the content of object oriented programming courses for distance learning. Their new model was designed in a way that provided more help for students to have interactive learning in compared with traditional classrooms (Khoja, S.A. 2009).

Fernando Alonso, Daniel Manrique, José M. Viñes proposed a three different models for e-learning java language programing course and evaluated the effectives of these models based on their collected data. After failure of the first two models, the moderate constructivism approach was as successful due to the consideration of psych-pedagogical prescriptions on teaching and learning (Alonso, Fernando 2009).

Gillet in 2005 initiated online available resources to sustain the evolution of traditional teaching to active leaning for some pilot courses at Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland. The main objective in this research was implementation of a hands-on experimentation in automatic control education, in order to simulate real situation in web-based environment. The result has shown that, virtual laboratories promote active learning with a flexible scheme. Their web-based collaborative experimentations is supported by pedagogical point of autonomous and collaborative learning and also were cost effective for this education (Gillet, D. 2005).

Baturay (Baturay, M.H. 2010), Rovai (Rovai, A.P. 2004) have implemented constructivism in the right way but the final comparison before and after is controversial. Simultaneously, they achieved more performance and satisfaction of students. In 2010, a course of introduction to computers offered by Department of Business Administration of the Distance Education

Program at a higher education institution in Turkey was based on problem-based learning of constructivism. The experimental group (C1) and the control group (C2) were compared in this research. Students who worked on problem-based projects felt much more 'connected' in compare to other class members in compare to the control group and they were more eager and active consciously or unconsciously while working based on collaborative approach, but the final examination result scores did not indicate any difference between the two groups. The main goal of this research was investigation about participants if they were self-regulated learners or not. Moreover, based on compared result, collaborative working can sometimes have negative effects due to have inactive and dominant students, so further studies need to be done to investigate students' characteristics and communication styles in the collaboration process of learning (Baturay, M.H. 2010). Rovai applied a combination of online learning and constructivist methodology for specific course and evaluated the results by students who answered to the 0 to 9 scale survey. The analysis results supported that online course designed based on constructivist epistemology can have a positive effect on satisfaction and performance of students. However, achieved grades by students can be heterogeneous in some way (Rovai, A.P. 2004).

Moss (Moss, N. 2010), Neo (Neo, M. 2005), (Hamada, M. 2008), Delia Baskerville (Baskerville, D. 2012) were somehow successful in applying the constructivism learning theory by ICT for distance students. Moss reports the success in delivering the Cisco Exploration Curriculum for both campus and distance education student at Open University of the United Kingdom (UKOU). His learning theory was based on constructivism which provided students with collaboration, learning through meaning in large scale number of educators, and the result of his achievement was successful (Moss, N. 2010).

In Neo's project, the results of students' feedback was satisfactory in the modern educational theory of his research, where he used learning theory as a movement to go along with constructivist-based paradigm and get distance from traditional behaviorist perspective of learning. Neo in his work used Malaysia's MSC as his case study to design and implement web-enhanced learning based on constructivist learning. He suggested that

students practice with a virtual network to find problems through a web-based laboratory and make critical analysis for network weaknesses. He also asked students to suggest solutions as improvements for the scenario. This is exactly what the concept of constructivism is so students have learned to create knowledge through student-centered in learning (Neo, M. 2005). Moreover, among all main positive achievements in constructivism there are also some other marginal benefits. For instance, to improve how to learn, increase teamwork, increase communications skills, and increase collaboration and presentation of results in the group or class (Neo, M. 2005).

There was research which was based on changes on the pedagogy of e-learning at the University of Western Ontario by Rosati that provides students with active, visual, and sensing learning preferences based on constructivist theory. The result was very positive after development the model (Hamada, M. 2008). Based on their final analysis, using online technology and ICT in education is an engagement of students in learning-centered and e-learning and tendency to have collaboration between students and teachers to produce and learn the new knowledge.

In 2012, a research has been done at Luleå University of technology as a starting point of designing an information security laboratories based on specific and systematic pedagogical approach Tero Päivärinta, Todd Booth, Sarfraz Iqbal. There is an explicit pedagogical approach of learning based on personalized system of instruction which has strong focus on flexibility by own pace in learning (Iqbal & Päivärinta 2012).

Cocciolo in 2011 used constructionism as a learning theory to place students in the role of designer during the instructional design of the Digital Archive Creation Project (DACP). This was done in order to determine if the constructionist pedagogical approach can have an effect on the students' perception in learning process or not. Participants were all graduate library science students from the Dalton cohort and the LHA cohort. The result positively showed the impact of students' perception of their learning and their skills, confidence and understanding of the topic and the overall understanding were significantly increased and the main factors which had an effect on the success of the project were collaborative

teamwork, individual effort and role of teacher as a facilitator and instructor (Cocciolo, A. 2011).

One problem that we are addressing is the following. Is there some other learning approach that can be used to improve the effective learning and increase student satisfaction?

7.7 Identification of critical Knowledge gaps

This section is concerning the identification of critical knowledge gaps in the reviewed literature and is based on our teacher's experience during 2012-2013, with regard to the data communications with security course.

The most important part of a literature review is in obtaining results out of the past research to define what we know about the research problem and what we want to know. This process is to find the knowledge gaps between previous research and what we would like to learn about in the new research. During our literature review, we found interesting points that have not been presented before, based on our reviewed papers. These factors can have a dynamic effect on increasing effectiveness in active learning for the data communication course. In other words, there was no prior research which we found, concerning data communication with security course based on constructivism learning theory at the University level. So, we developed it as a class of field problem for data communication and network courses.

1. **No explicit rule of taking classes synchronously**

   In the reviewed papers, there was no clear rule to require distance or on-campus students to take class synchronously. Students' interactivity is the main agent while we are trying to increase effectiveness of active learning by having a new e-learning model. In the previous research, there was no mention of the requirement, if any, as to how many live sessions the students must attend.
2. **No requirement to be active in a live lecture**

None of previous researches had discussed a requirement of student attendance in live group sessions. Without student attendance, the teacher is unable to give feedback in his mentor role and the students will not be able to participate, as active students. For distance classes, students should be required to attend via the Internet with a microphone and web camera. Being active via talking and presentation is a major principle of active learning in constructivism.

3. **Accomplish collaboration by dedication of time for each individual student**

   Active learning means to have interactivity between students and students need to have time to show perform this collaboration. However, none of previous research we reviewed, considered the amount of time required in each lecture, for collaboration. The number of students can be varied in different universities and between classes. For example, Todd had 90 students and the group sessions were 90 minutes. There were two group sessions per week.

4. **Having hands-on lab exercises as part of the examination**

   If students work actively with hands-on exercises, they should be assessed, examined and graded via similar exercises in virtual environment. Based on our literature review, no one has thought about how we can assess, examine and grade students in the same virtual environment during examinations.

5. **No explicit role of students and teacher**

6. **No syllabus changes in terms of information security engineering**

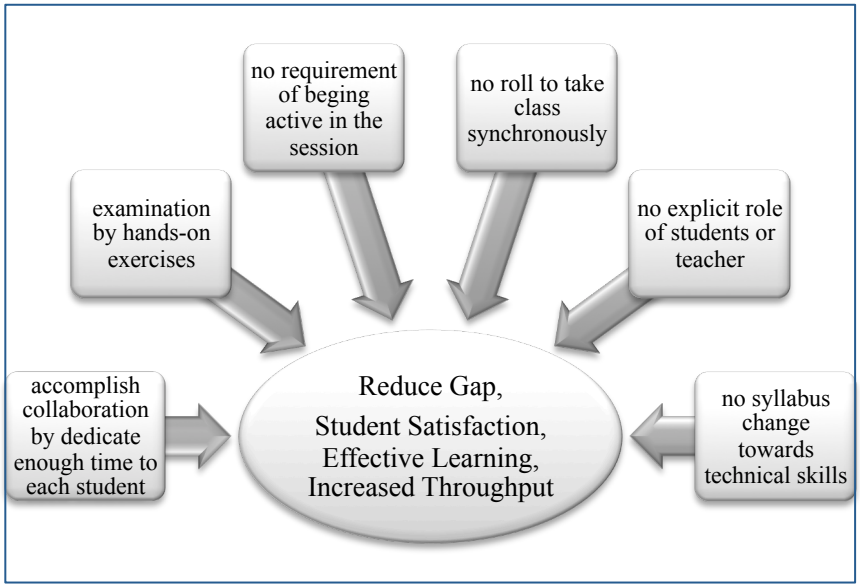


Figure 5 Knowledge gap

Through on going reflections during the BIE stage, ADR team identified there are some design principles that we would realize them to the life cycle perspectives of our e-learning model.

Principle 3: Reciprocal Shaping. Here we find inseparable factors of e-learning model for data communication and security course as a primitive IT artifact and organizational context in recursive cycle of iterations. Passive role of students, over-active role of role of teacher, and lack of hands-one exercises in the data communication with security content was considered the main problem by practitioners and researchers in early stages of iterations.

Principle 4: Mutually Influential Roles. Define importance of mutual learning among different students or participant. This helps to minimize the gap between knowledge of theory and technology with practical hypothesis and organizational practices. So, ADR team includes ADR researchers and teacher as a practitioner and students. Also, Practitioner and researchers should be expert in theoretical, practical and technical perspectives.

Principle 5: Authentic and Concurrent Evaluation. Evaluation is always a part of research process in ADR. Any changes in IT artifact and organizational context in each stage needs a new evaluation process. It is nature of ADR that moves from alpha version to beta version.

Note that ADR is not our own design principle. We are using ADR as an approach, concerning own design principles, which are based on constructivism and constructionism.

We would name beta version as e-learning prototype which is resulted of constant changes based on students' behavior and assessment of iterative process in ADR. This prototype evaluated firstly with ADR team and then developed to practitioner and students. Besides that, we have recorded fundamental changes in every iterative cycle in the following parts.

The following diagram shows the process of building, intervention and evaluation from first step to the final step.

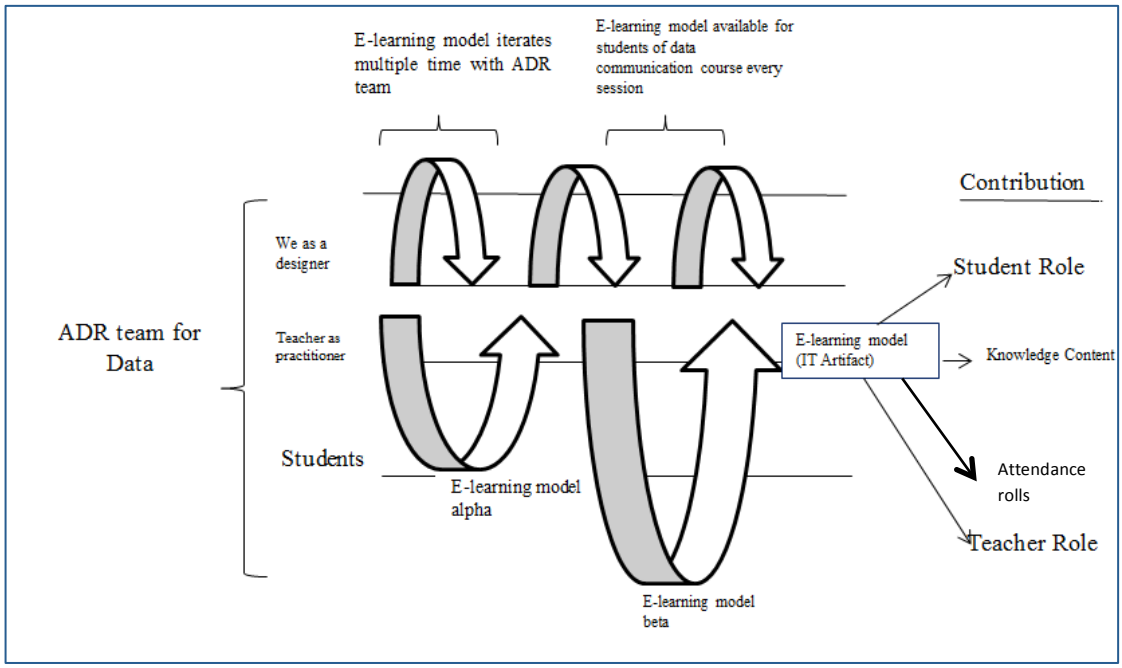


Figure 6 Processes of building, intervention and evaluation

7.8 Primitive design principles as Alpha model

Based on feedback and the evaluations of the iterative process we found out that there are three important factors that come up as emergences in our new e-learning model, during the alpha phase. These principles helped us to reach the intermediate design of Alpha model

7.8.1 Teacher role: teacher plays in two positions in e-learning model

1. **Teacher's role concerning instruction**

As we implied before, to have more active learning we act based on constructivism learning theory which has strong focus on active learning. In constructivism, the teacher is the heart of theory. In the ordinary teacher's role, it is expected that teacher be coacher or supervisor for the students. What we understood by applying the e-learning model in the first stages was the change in the teacher's role. Herring acknowledged that teachers who want to implement a learning theory based on constructivism need training in the creation of authentic and student-centered lessons (Herring, M.C. 2004). Because, the effective control of classroom based on active learning is more qualitative in scientific thinking and analysis of knowledge. Rovai believes that, course objectives and goals must be identified by the teacher and then demonstrated to students as course assessment in order to inform students how to achieve these objectives. Also, designing didactic objectives to motivate students to be active in learning process is a very critical duty for teachers. Moreover, the transference of knowledge from teacher to student has effects on active learning. Besides that, assessment of students at first and end of the session help teacher to evaluate students' knowledge. Consequently, as a main agent in active learning, teachers should be trained in systematical way to avoid having only traditional position as instructor/teacher. As we pointed out in the literature review, changes in technology alone does not guarantee any change in the nature of instructional classroom to constructional classroom via active learning, and the ability of teacher to integrate technology to proper curriculum is essential (KeenGwe, J. 2009). Also, students' previous knowledge can have an effect on the learning process positively or negatively (Moreno, L. 2007). However, prior knowledge from one

student to another is different. So, being aware of initial misunderstandings of students helps teacher to provide relevant and customized material for them (Rovai, A.P. 2004).

2. Teacher in a Mentor Role

Note that the following was not our initial hypothesis but came up as new motivation during the thesis process.

In the second role of teacher in his/her mentor role, the teacher must be able to reflect on social curriculum learning pedagogy and let students to be involved actively in the learning process by conducting group discussion, provide guidance of students indirectly to the main content of new knowledge, stimulate students to share their ideas and comment on each other's, assimilate prior and new knowledge and make a challengeable environment for students to reflect on each other. The following diagram shows the teacher's responsibilities in each separate role:

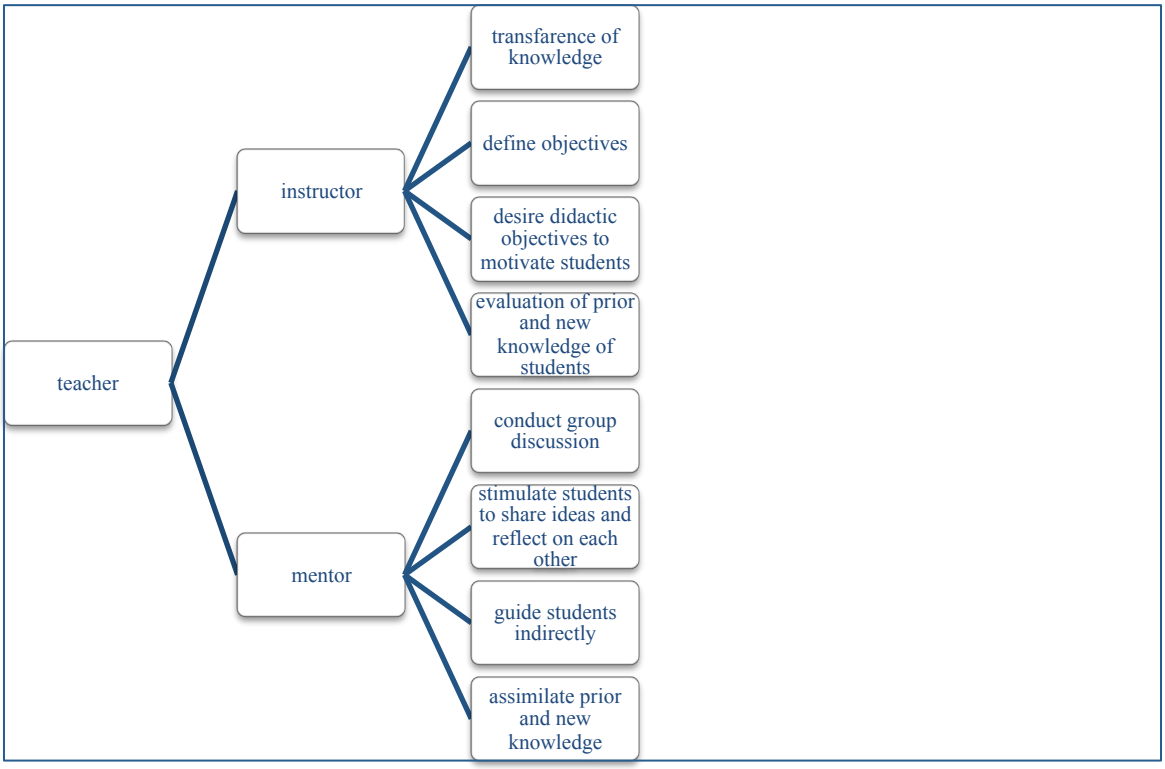


Figure 7 Teacher positions and responsibilities in each separate role

The following diagram shows explicitly how the teacher's role changes from instructor to mentor in each phase:

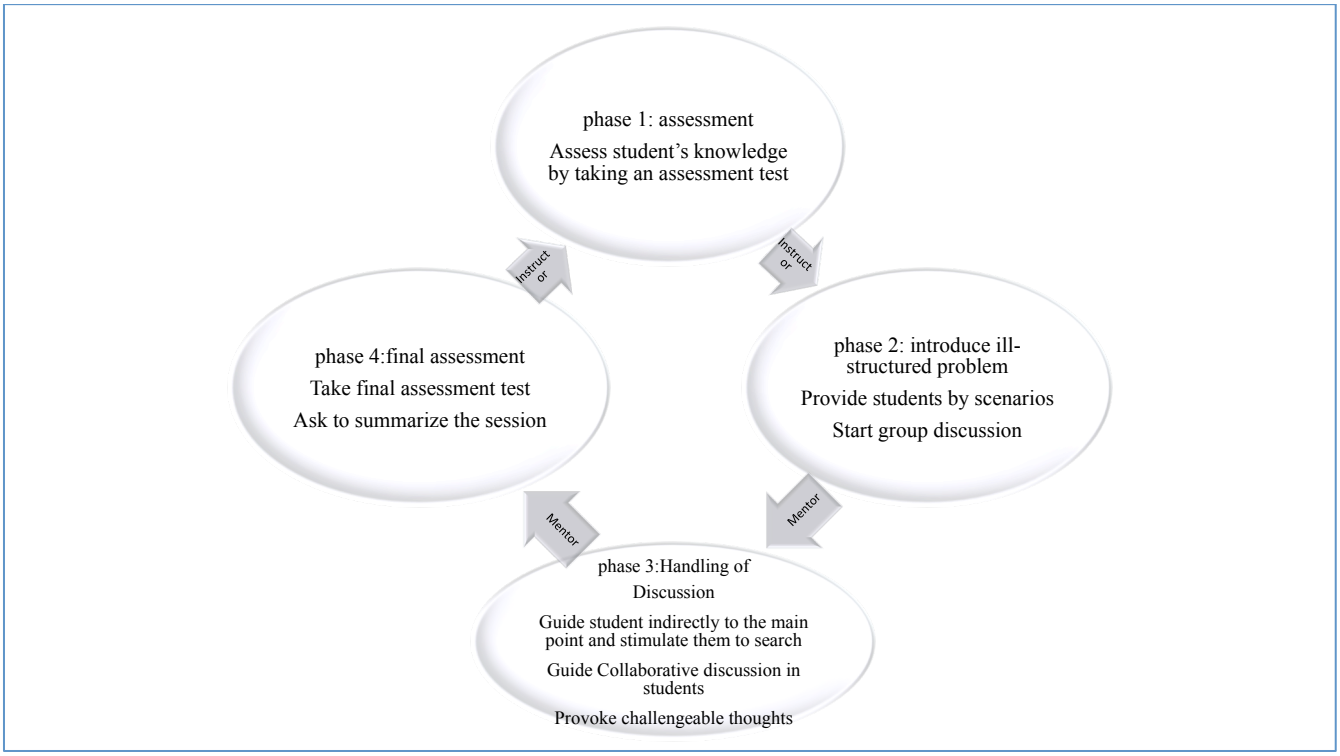


Figure 8 Explicitly how teacher's role changes from instructor to mentor

7.8.2 Student role: student position in active learning

In iterative loops, we found out that students need to learn how to develop pivotal higher order and critical-thinking skills to move them toward meaningful learning (KeenGwe, J. 2009).Creativity in individual means the ability of thinking with newer perspectives to rise up new questions and facts about ill-structured problem and generalizes innovative and meaningful idea (Aqda, M.F. 2011). Creativity is a variable factor that depends on thinking style, personality and intelligence in each student. In our e-learning, we provided some conditions to help students to make new knowledge through doing hands-on exercises. Moreover, Fosnot believed that the main goal for students in constructivism learning theory is helping students to re-order and order, built and re-built new knowledge (Fosnot, C.T. 1993).

In group discussions, misconception in students can be solved by sharing their ideas and get feedbacks from other classmates based on constructionism. In fact, the student mastery does not appear through repetition of specific practice unless student learns to understand

conceptual meaning of problems and try to create knowledge. There are two different perspectives of constructivism and constructionism that consider the individual cognitive process which implies construction of knowledge in individual people and social co-construction of knowledge which emphasizes collaboration of knowledge building. As a result, expressing the constructed knowledge for other peers in a group is constructionism or co-construction of knowledge collaboratively.

The relevance of the following figure is that it shows the relation between the Initiate phase, the instructional phase, the collaboration phase and the evaluation of knowledge, among other relationships.

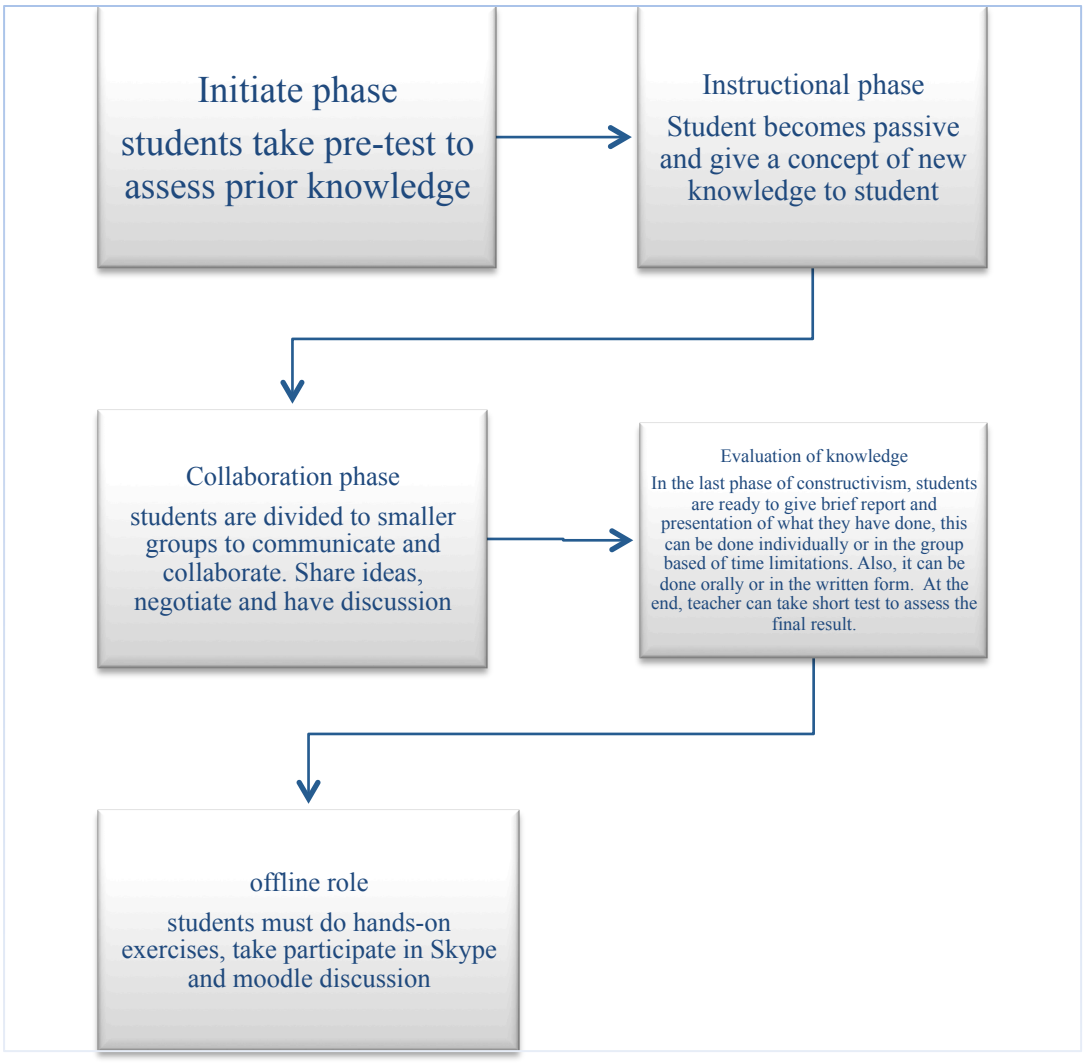


Figure 9 Student position in active learning

7.8.3 Knowledge content: knowledge content-reconstruction of course syllabus

To provide hands-on exercises in course syllabus for students to practice with technical exercises we required students to use the CompTIA Network+N10-005 Simulator. CompTIA is the largest independent, vendor-neutral engineer certification organization. Students were required to practice with real problems in a virtual environment in order to get enough job skills and increase effectiveness in learning. The CompTIA Network+N10-005 Simulator helps students to make connections between what they have learned and technical practices.

CompTIA Network+N10-005 Simulator provides:

1. Useful activities and concrete examples to get professional skills in security engineering
2. Relevant technical exercises to help students to make a connection of what they now before (prior knowledge) and what they are learning as a new knowledge
3. Instructions, videos, quizzes and explanation in the CompTIA Network+N10-005 Simulator graphical mode are very interesting for students to stimulate them to follow the later stages.

One obstacle that came up was that the software did not properly install on all students PCs. So the students needed support, in order to properly install the program. However this specific program was not officially supported by the University support service, so they would not help students. So the teacher Todd was required to provide the required student support to help students install this program. However the teacher was not allocated any hours for this activity. This problem was solved by the teacher Todd working overtime without pay.

As stated earlier, another major obstacle was that it took many hours for the teacher to master the required knowledge, in order to create any required hands-on labs. The University did not allocate the teacher any hours for this activity. This problem was solved by the teacher Todd working overtime without pay.

It should be pointed out that we did not create design principles. We applied design principles based on our application of ADR, constructivism and constructionism. Further we applied these in a more specific and perhaps very unique environment.

Here is the relationship between the student role, teacher role and knowledge content:

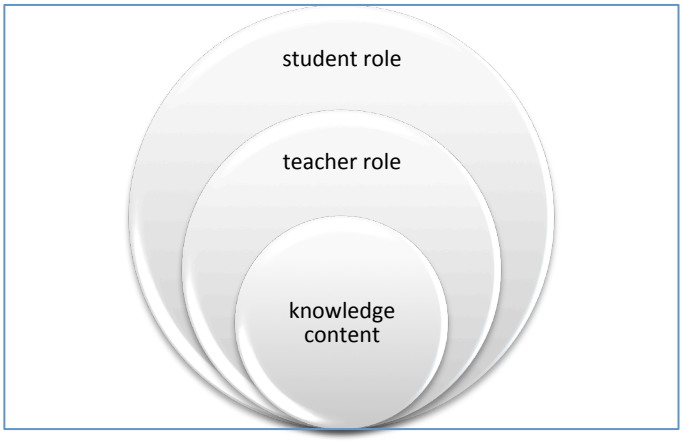


Figure 10 Alpha model principles

7.9 Beta model

In the beta model, when e-learning model is under test, we involved students more in the process of learning and moved towards active learning and comprehensive interventions. So, we have both anticipated and unanticipated design principles consequences. The following figure shows the beta model.

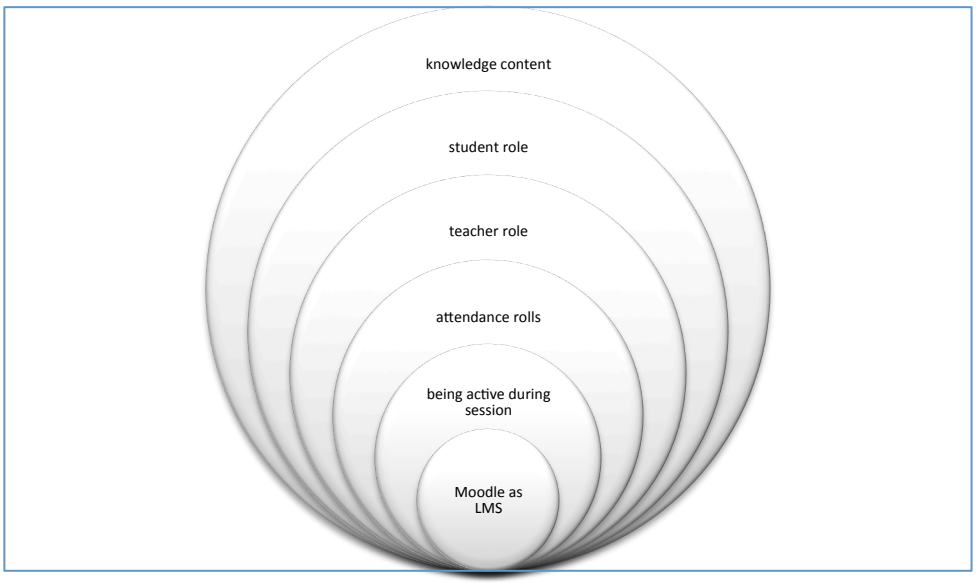


Figure 11 Beta Model

7.9.1 Anticipated principles in Beta model design:

1. being active during session
2. lack of time
3. learning management system

7.9.2 Unanticipated principles in Beta model design:

1. Teacher time required to master material
2. attendance roll
3. examination with hands-on exercises

The following table expresses stage two briefly:

As was stated earlier, we did not realize how much time was required, in order to create hands-on labs. Further, there is another issue with regard to the fact that many teachers will not have the required technology knowledge in order to create and/or grade the hands-on lab assignments.

Further, as stated earlier, there is an issue with ADR, concerning the IT-Artifact. Based on ADR, the IT-Artifact is one of the main aspects. However, in our research, we also took actions which were not specifically tied to any particular IT-Artifact. To overcome this obstacle, we followed some of the principles of constructivism and constructionism, which do not have any IT-Artifact as the central concept.

		artifact
Stage 2: BIE		
Principle 3: Reciprocal Shaping	Over-active role of teacher, passive role of students and shortage of hands-on exercises were caught by practitioners and researchers in the early stages of design of e-learning model for data communication course.	**Alpha version:** the artifact is designed based on reciprocal factors in e-learning model to reflect on having better approach of learning in data communication and security course by adding hands-on laboratory and motivate students to be active in learning process **Beta version:** e-learning prototype which is resulted of applying alpha model in iterative processes. We decided
Principle 4: Mutually Influential Roles	ADR group contains students, practitioners and researchers who are skilled in technical, theoretical and practical perspectives of improvement of e-learning model for data communication by adding some technical hands-on labs and change	

	the pedagogy approach of learning.	to put attendance rolls for students who take this course as students need to take the course synchronously to have active role in knowledge construction process.
Principle 5: Authentic and Concurrent Evaluation	E-learning prototype is designed and evaluated with ADR researchers in the first hand and expand to practitioners and students.	

Table 6 Summary of Stage 2: Building, Intervention, and Evaluation

8 Stage 3: Reflection and Learning

In this stage, we have a better conceptual idea about how to address the problems. During the course there were some factors, such as new emergences in every session, where we applied the e-learning model. We analyzed students' behavior and their feedback, via the system and made new changes. Every new emerging factor can have an effect on our system with the result of more or less effectiveness of learning. So, we classified emerging factors in order to anticipate and understand emerging factors and find solutions in order to add them to the Beta model.

Taken tasks in stage 3:

1. Design and redesign of e-learning model
2. Evaluate result after each iterative process of change
3. Analyze results and compare it with ideal goals

Principle 6: Guided Emergence. This principle emphasizes the preliminary design to shape organizational framework. Substantial changes in IT artifact apply as a group of changes. So, the outfit and nature of e-learning model is recognized in this stage but there are some other elements discovered as emerging factors appear. Thus, the new requirements apply to new factors as emergences to current e-learning model of BIE are introduced.

The following table is the summary of the Reflection and Learning stage:

Stage 3: Reflection and Learning		**artifact**
Principle 6: Guided Emergence	The nature of e-learning artifact is shaped. Also, some emerging factors are adding to the previous artifact.	***Emerging Version and Realization***: new requirements for applying new emerge to beta version of artifact are introduced.

Table 7 Summary of Reflection and Learning stage

8.1 Solutions for anticipated factors as design principles of e-learning model

1. Being active during session

In order to be active, students must be equipped with microphone (and optionally with web camera) and participate in most live group discussions. This is a requirement of being active in the learning process and we have expected this factor to jump up as a one emerging factor. So, there should be a roll for every student to participate in discussions and comment on other's idea and share their own ideas with the others.

2. Lack of time

The group sessions are 90 minutes and there are 90 students. This would only allow each student to present for 1 minute. This would require all students to listen for 89 minutes (89 other students). Our solution was to break students into groups of two. This allows for students explaining for 22 minutes and listening for 22 minutes. This still allows for the teacher to present for 45 minutes. Based on a random algorithm, the teacher can also request one group member to present to the class. If students know that they may need to present, the students will be more active, in learning, during the small one on one group sessions.

3. Moodle as a learning management system

Moodle is customizable tool of learning which contains different resources and activities in form of quizzes, assignments, polls, wikis, forums, glossaries etc. Moodle can be used to support constructionism and constructivism. It provides students with essential tools to

express their ideas and make them shareable and tangible. Students can easily communicate with others by expressing their ideas. Moodle also has some constructivist surveys which are easy to administer. We found these surveys helpful during our process. So, using Moodle as a proper learning management system and external aid for students is more pragmatic and structured than Piagot's constructivism approach alone.

One question the reader may have is why is the Moodle LMS in this paper? The simple answer is that via the Moodle LMS, it took perhaps 5% as much time to collect and analyze the results of our student surveys. Moodle cannot do anything that can't be done manually. So, in summary, the Moodle LMS is simply a tool that allows us to work much more efficiently in our research. Note that LTU is planning to replace their current LMS (Fronter) and LTU is considering to replace it with the Moodle LMS.

8.1.1 Social constructionism as a referent in Moodle

In a true collaborative environment of teaching and learning, learners can be both potential teachers and learners. In fact, learners are allowed to share their ideas by other educators and help them to participate in different discussions to move towards social constructionism.

1. Learn based on expressing or creating something for others

Learning by doing in constructionism is the main and fundamental principle of teaching and learning. In traditional distributed distance learning of InfoSec there is little opportunity of dynamically learning such as live discussion or group activities which help learners to get a better understanding of an object by creation of it. Moodle makes it possible for educators to see what others are constructing as a powerful learning experience. Moreover, it is a fact that educators learn more by observation of other peer's activity in a group. Moodle helps to reach to higher level of multi-dimensional immersion in learning by taking participation actively in raising questions and bringing up new and relevant subjects to main subject. For example, Wikis in Moodle are collaborative-built pages for group work and negotiations. Also, glossaries are collaborative- built pages of different concepts and definition which appear during a course.

2. Moodle as a Social Constructionist Approach

Constructionism claims that learning can be more effective in constructing something for others to experience. In fact, explaining or trying to teach someone else causes iteration and consequently have better understanding of the integrated concept in mind. When, a group of people try to learn a new concept collaboratively constructionism extends to social constructionism which is Moodle is based on. Social constructionism via Moodle helps educators to have different behaviors which are needed when immersing in new knowledge. Objectives in the new knowledge in a challengeable pattern. We must find some common points of knowledge and accept subjectively the new knowledge and construct the new knowledge.

Social constructionist pedagogy is divided into four principles by Alier (Alier, M. 2010):

1. Constructivism: new knowledge constructed actively and dynamically by educators in their interactions with environment.
2. Constructionism: learning is most effective when educators and learners try to construct something for others to experience.
3. Social constructivism: when educators in a group construct things for others. This helps all members to learn how to be a part of group culture.
4. Constructed behavior: constructed behavior is an approach which is constructed by two other sub-approaches of “separate behavior” and “connected behavior” and is sensitive to the needs of the appropriate sub-approach according to the current situation. Principally, separate behavior tries to be more factual and objectives while connected behavior tries to be more subjective and empathic.

8.2 Solutions for unanticipated factors as design principles of e-learning model

1. Required Attendance

In active learning students should be present to be as a part of the learning process. However, Based on LTU InfoSec Program handbook students are not required to attend the class synchronously. I.E., students are not required to attend any group sessions. If we want to apply this model to increase effectiveness in learning, our hypothesis is that we should have the following new requirement:

New requirement: Students should be required to participate in most of the live group sessions.

2. examination with hands-on exercises

When we use hands-on lab exercises to train students, how can teachers assess, examine and grade students, using a similar hands-on lab examination? Pearson Publishing is working on a solution and Todd is on the Pearson Review Committee.

In the following section, we present a table from newly anticipated and unanticipated emerging factors for readers to better understand.

Anticipated emerging factors	**Consequences**
1. being active during lecture	1. students should be equipped by microphone and optionally by web camera 2. students should be required to participate in live group discussions, and give comments on other's idea
2. lack of time	1. divide students to smaller groups 2. ask one students randomly in a group to give a summary at the end of sessions 3. take a small examination at the end of each lecture to assess students' knowledge level
3. Moodle as a learning	1. more social constructionism

management system	2. get benefit and learn more out of other's idea 3. share ideas 4. Have more effectiveness in learning based on constructivism
Unanticipated emerging factors	**Consequences**
1. attendance roll	1. If students take the data communication and security course, they should be informed about the attendance requirements 2. students must take classes synchronously to be active during group sessions
2. final assessment based on technical lab questions	New technology is needed in order to assess students, based on hands-on labs

Table 8 Summary of anticipated and unanticipated emerging factors in design principles

9 Stage 4: Formalization of Learning

We now formalize the learning results and generalize it to the class of problems, express accomplishments in IT artifact and analyze outcomes in a final formalization of learning. Briefly, defining the original problem, reconceptualization of solution and then reconceptualization of learning from specific group of solutions for specific group of problems are the main activities in the fourth stage of ADR process.

Principle 7: Generalized Outcomes. Along organizational change with the implementation of IT artifact, generalization of outcomes is done. In summery we found that in our specific environment, we were able to improve students' satisfaction and performance. However, our environment was only for a single course, which was data communications with security. We believe that our research can be generalized in the following way. We believe our research results will receive similar results for other computer science types of courses, where hands-on labs would be appropriate. Related to our generalized outcomes, we would like to comment on our contribution. We were unable to find any similar research, such as ours, which was based on ADR, constructivism and constructionism. Therefore, our research is unique. We can also state that our finding are consistent with ADR, constructivism and constructionism's expected findings.

With regard to how we implemented the lab, we focused on having the students perform the labs, which were found in the existing IT Artifact. Additional, the teacher Todd acted as a mentor to assist students.

Taken actions in stage 4:

1. Pluralization of learning concepts for a group of problem
2. Share and assess outcomes with practitioner (teacher)
3. Pluralization of results as design principles
4. Pluralization of learning with selected theories

5. Pluralization outcomes for distribution

The following table is the summary of Formalization of Learning stage:

		Artifact
Stage 4: Formalization of Learning		
Principle 7: Generalized Outcomes	Positioning e-learning model as an instance	***Ensemble Version***: A final design principle for e-learning model and conditions are set.

Table 9 Summary of Formalization of Learning stage

9.1 Define components of visualization according to Dr. Sanford Gold

We cite the table of "Constructivist Components within Virtual Campus" from Dr. Sanford Gold in his famous paper" A CONSTRUCTIVIST APPROACH TO ONLINE TRAINING FOR ONLINE TEACHERS" (Gold, S. 2001):

- accommodation of current structure to new knowledge in each session the data communications with security course
- assimilation of new event with related knowledge and prior meaning in each session
- equilibrium and apply balance between external world and hands-on exercises in simulator
- disequilibrium of new invent without achieving a current equilibrium

It should be noted that we did not create the hands-on simulator. Therefore, none of our own design principles were specifically used in the creation of the hands-on simulator hands-

on exercises. Instead we determined that the IT Artifact, the hands-on simulator properly implemented some of the constructionism and constructionism principles.

Processes	Instructional Principles	Components of e-learning model
Assimilation	• Assess prior knowledge of each student in data communications with security course to find misconceptions in students as a and give background to student to make student ready • Guide learner to learn how to work with CompTIA Network+N10-005 Simulator and Moodle • Support student to express problems friendly and get feedback by others • Mix all small learning activities to a larger task that student understand the relation between small tasks and bigger task as a complete learning activity	• Take Pre-test • do brain storming and make students ready to accept the new knowledge by provoking their cognitive ability • Ask Challengeable and Facilitative questions • Have Non-grade activities during session • group discussion and Emails • FAQ • Have prepared Schema • Introductory about course information and Define syllables and Specify resources and book, PDF • Provide Live chats and discussion forums • invite student to comment

		on each other's idea
Accommodation	• Provide students by ill-structured scenarios and proper learning and challengeable environment • Design tasks and learning environment in a way that provoke learner to reconstruct new knowledge individually or collaboratively for deeper understanding • Encourage student to suggest suggestions in problem-based learning and be innovative	• Quizzes for reinforcement • Modularize Content to scaffold learning • Compare ideas and find common or uncommon points • Team work assignment • Ask student to write report after each session or give brief of session • Do hands-on exercises by simulator after each session • Ask student to design exercise for each other
Equilibrium	• Design an authentic tasks to make active environment for learner and prepare student learning through problem-solving process • Provide an opportunity for student to criticize or reflect on the learning process and learning content	• Team working • Discussion in the group • Evaluation of team work • Feedback forms • Freedom of student to evaluate mentor
Disequilibrium	• Provide student to have permission to change, redo and improve exercise • Challenge problems	• Flexibility in learning process to correct or change the answer • Post-test

		• Evaluation of student with hands-on exercises in exam time

Table 10 Constructivist Components through virtualization

10 Results

In this part, we evaluate and compare the result of final grades in 2012 and 2013 for data communication with security course to investigate about student throughput and final grades of students.

10.1 Student throughput in 2012 compared with 2013

Based on evaluation, we have wonderful results when we compare students' throughput in these two years, concerning the data communications with security course.

2013 final examination throughput: 50 out of 77 = 65%

2012 final examination throughput: 11 out of 43 = 26%

So our results show that student throughput was increased by over 100% !!!

10.2 Compare final grades of students in 2012 and 2013

Based on our results:

1. in 2012:

In 2012, 11 students took the exam and we have:

2-G, 2 out of 11 or 18%

9-VG, 9 out of 11 or 82%

2. in 2013:

In 2013, 54 students took the exam and we have:

2013, 10-G, 10 out of 54 or 19%

2013, 40-VG, 40 out of 54 or 74%

11 Discussion

Based on Webb providing students with real world experiences shows the richness of distance learning and increases interests between students (Webb, M.E. 2005). Also, we reviewed Baturay project which was successful in applying collaboration learning approach because students felt more understandable connections between course material and reality so his approach stimulated their interests (Baturay, M.H. 2010). Improving professional skills of students to train to be information security manager and how students could use learned topics in the real world and make connections between what they have learned and what exists in reality were our main objectives and in Ultnir‘s paper we resulted that constructivism is an epistemology that construct relations between human learning and nature of knowledge. Moreover, James M. Hanson & Kenneth E (Hanson 2008) got salient results in applying constructivism to increase professional skills of students. Otherwise, if the our course material wouldn’t be interesting enough, we could have failure like Chen’s project which had less consideration on curriculum on information security courses (Chen, F.-G. 2011) . Also, we used the result of failures in Tenenbaum’s project (Tenenbaum, G. 2001), that was ignorance of students’ needs so we tried to consider all dimensions of students’ needs to be information security engineers, in our model.

11.1 What were our initial constructivism principles?

In our e-learning model for data communication and security course, to increase the throughput performance of students via active learning was the highest goal so relevance of course material to technical skills, how students reflect on the learning process, how they have interactions with tutors and other peer, how tutor motivates them and how they get the main concept of each other’s message are considerable and were measured to improve our model. We tried to change the roll of students from passive recipients of pre-formed knowledge which was transmitted by the teacher into more of an active agent in the learning process. In fact, our dynamic view point to learning process is reaching to new theory of learning and knowing based on social constructivism which considers learner as an

active conceptualizer with rather highly interactions with learning environment, other peers and teachers. So, active learning via our new e-learning model is epistemology in which learners collaborate to construct or re-construct new knowledge within a mutual inquiry and communicative competence is a vital factor for both peers and students in active learning.

Based on the previous existing literature, we found out that the teacher can play two roles instead of one traditional role, as just being a knowledge passing teacher. We decided to add a new role for teacher to play as a mentor during session so this new change in the teacher's role gave students an opportunity to be more active in one part of the learning process. For example, they can give comments, share their ideas, and learn thorough problem-based process when others express their ideas about specific problems. Moreover, students attain enough self-confidence to be innovative and themselves can create new knowledge for each other. Based on what we attained in result section, we could successfully increase students' throughput in 2013 in compare with 2012. Also, students became more confident to take the exam in 2013 based on the new artifact or new model of learning in compare with the number of students in 2012 who took an exam on time. We tried to design a model for the students' role in learning process and give them more chances to become one part of active learning. Besides that, we added a simulator for students to give them a new opportunity to have access to practical and virtual network problems so they were more experienced in technical skills and this was the only main difference between last year's course in 2012 and the new course in 2013. We reconstruct the course content by adding a network simulator. During interventions, there were some problems such as being absent of students during live lecture, or students didn't have access to microphone and camera to jump up in group discussion. So, we added some roles as a limitation of absence for students and essential needs to have microphone and camera and ask all students to be active during session.

We classify different feedbacks that we attained from students' behavior and our observations from our IT artifact in following:

11.1.1 Success in Relevance of course material increases motivation, interests, professional skills in students

Based on analysis from the questionnaire, final grades and student throughput we had successful model to increase motivations, interests and professional skills in students regarding course material and encourage them to do hands-on exercises in simulator in a way that it focuses on interesting issues and useful for their professional skills. According to Eisenberger (Eisenberger, Robert 1999) giving value to increase intrinsic can increase or decrease the performance directly. Yeager believed that increase motivation in students encourages them to initiate ideas and new solutions and also, Ryan (Ryan, R M. 2000) consider intrinsic motivation to effect on exploratory behavior. We believe that an important reason for this success was due to the fact that the teacher Todd acted as a mentor and was well accepted by the students, in that role.

11.1.2 Have high tutor support to motivate, stimulate and encourage students in active learning

Based on our analysis, nearly half of students were always stimulated and encouraged by teacher when tutor was in his mentor role. It was an incredible success in our model that the teacher could model good discourse and the role of students was more active during several sessions. The teacher guided group discussions and provided students with immediate feedback which help them to great interactivity in the presence of teacher.

11.1.3 Motivation and encouragement of students by teacher in the light of literature review

Based on our literature review Ultnir (Ültanır, E. 2012), Yeager (Yeager, R.E. 1991), Papert, Sara de Freitas (De Freitas, S. 2010), Balta (Balta, O.C. 2009), Jara (Jara, C.A. 2012) emphasized in encouraging students by teacher in challengeable environments, asking students to suggest solutions for ill-structured problems, encourage students to collaborate in group discussion, representation of what they learn, consider students' motivation and perception.

For instance, James M. Hanson & Kenneth E. (Hanson 2008), Yang (Yang, Z. 2007), Shakeel (Khoja, S.A. 2009), Neo (Neo, M. 2005) were the projects which used constructivism as their kernel theory and had satisfactory results in teacher's role to consider students' feedback, increase social skills in group to increase satisfaction and performance of students in team, provoke students to challenge and have more collaboration.

Finally, we can say that teacher plays very well in both his position as a mentor and as tutor for students to increase and motivate their participation in active learning, provide challengeable discussion, increased satisfaction, had collaboration in team group by making students active in learning process to discuss their ideas. We could have also, comprehensible and related course material in both lectures and hands-on exercises in simulator which trained students to obtain valuable technical engineering skills.

11.1.4 Comprehensible and understandable message for both teacher and students from students' viewpoint

Almost half of students made good sense of both tutor and other peers in active learning. This can increase the level of understanding and also increase the performance of students when everything is clear for them to understand.

Finally, based on our results from final grades and students throughput in 2012 and 2013 for data communication and security course we can prove that our model was successfully in applying supposed hypothesis.

11.2 what are the new design principles as emerging factors in ADR process:

1. Design e-learning model as an IT artifact
2. For three different audiences: students, instructors and universities with distance learning
3. Our research has scientific contribution in solving practical and theoretical active learning for distance education
4. Contribution the IS knowledge bases to make fundamental methodologies

5. Define attendance rolls, students' role and teacher's role in active learning
6. Design of a new theory for our IT artifact based on kernel theory (constructivism approach) and expresses it through Gregor's framework "build a new theory".

11.2.1 Try to help students to find the logical relationship between their hands-on exercises and the real skills to be information security engineer in future:

In this section we present some rational relationships between technical skills and course content, increased motivation in students to reflect upon each other, increase interactivity and collaboration between students to have group learning.

Based on what we attained from students' feedback, we should make the following pedagogical changes in our teaching approach:

In the result of analysis, we found out that more than 66% of students could often or almost always make a connection between what they learned and professional skills. It was huge success in our model. Based on previous work of Gillet in 2005 (Gillet, D. 2005), we found out that implementation of hands-on experimentations can stimulate students in web based environment. That was the reason that we used CompTIA Network+N10-005 Simulator for students to have ability to do hands-on exercises.

11.2.2 Interactivity and relationships between students in the light of literature review

Based on Crotty, one way to shift from traditional classrooms to active learning approach is emphasize the collaboration between students and encourage them to have reflection on each other in experimental learning (Crotty, T. 1997). Also, De Freitas (De Freitas, Sara 2010) implied about socio collaboration between students to get success in web-based technologies. Moreover, Ackermann (Ackermann, E. 2001), Ben(Ben-Ari, M. 1998), Gillet (Gillet, D. 2005), Jara (Jara, C.A. 2012), Sara de Freitas (De Freitas, S. 2010), Mikropoulos (Mikropoulos, T A. 2011), Girvan (Girvan, Carina 2010), Papert clearly expressed the importance of collaboration, interaction to have the sense of being in physical campus and

share ideas to get feedback and comments, deeper understanding in group discussions as most important principles of active learning in constructivism and constructionism.

But, interactions between students were weak and they didn't encourage each other to think critically about other's idea and comment on each other. So, social collaboration between students must be studied again to increase in order to have higher rate of exchanging information between students.

For instance, the Tenenbaum (Tenenbaum, G. 2001) project failed because of lack of interactions between students in collaborative learning. However, we had in literature review successful projects such as Gillet (Gillet, D. 2005), Rovai (Rovai, A.P. 2004), Neo (Neo, M. 2005), James M. Hanson a & Kenneth E(Hanson 2008), Baturay (Baturay, M.H. 2010) Rosati which had considered collaboration, team working, communication between students, social interactions to increase performance of students. So, we decided to increase collaboration between students after we analyzed our results. Try to make environment more challengeable which temps students to take participate actively in group discussion and reflect on each other. We have to find a way to encourage students to reflect and comment on each other and this may need further research.

11.3 Evaluation

One of the extensive evaluations we performed, was concerning the student surveys. One main survey is titled Attitudes towards Thinking and Learning. The other survey is abbreviated as COLLES. It was through the use of these two surveys that we collected and analyzed a great deal of student feedback. Our finding in this thesis are based on these two evaluations. We also performed an evaluation of the official end of course evaluations which were given out by the Luleå University of Technology, which is performed after each course. It was through these evaluations that we collected a great amount of data. Much of the data we evaluated is found in chapter 15, which is titled Tables.

12 Conclusion

Our main goal is to obtain higher performance by applying constructivism via active learning. Our main concept of argumentation will first be clarified, to the reader. In a logical argumentation, someone who claims something tries to persuade the opposite side by acceptable reasoning. Towards our research question to get higher performance via active learning, debate and argumentation can help students to take active part in the learning process. So, the way teachers conduct argumentation between students can impress them to have better discussion and the role of teacher in guiding argumentations and get results in comprehensible language can affect discussion. If students play devil's advocate role in their group discussion, automatically students push towards testing the original argument and identify weaknesses or strong points in discussion. This is exactly what constructivism/constructionism intends to motivate students to be as an active agent in the learning process. Being socialized is one purpose in constructivism to encourage students to be as a part of active learning and seek for truth, so the first small presentation of each students about his/her history and experiences help other students to know each other better and help them to know who has special experience in the real work about specific problems. This also facilitates active debate with each other about specific issues. Encouraging students to know the reasons of why other people may think oppositely is a part of having more performance via active learning. Knowing positive and negative viewpoints helps students to know the topic of discussion better and them towards active participation in discussion and active learning because it leads them to know more dimensions of specific topic in lecture context. Based on our literature review, we found out that collaboration in learning has positive effects on performance of students in active learning process. So, applying active learning helps us to develop more collaboration and directly effect to increase performance of students in learning process. As there is an increase in performance via active learning, collaboration of different ideas can help us to

reach to more dynamic learning. So, the e-learning model must be designed to support more collaboration and motivate students to think about other's perspectives of specific matter.

To encourage students to participate in the active learning process, one critical point is try to minimize anxious and worries in social situations. Students must feel comfortable to express their ideas even if they are not correct. So, teacher's role can effect on students' interests and help them to get rid of solitary interests and motivate them to join to the group discussion. Curiosity to know other's beliefs shows that students can be more familiar with the things that other people tend to be attracted and interested about specific matter. So, the collaboration and sociality help students to learn new things. Based on our literature review, active learning does not mean to be far from reality whereas it is a way to get closer to the reality to get higher performance in learning. So, in the students' position, it is important that think more objectively than subjectively. As a result, students learn to how to collaborate in social learning but in more positive manner.

Providing challengeable situations is a vital part of active learning. How to motivate students to discuss opposing ideas and how to control the discussion and inject new topics in, and at the appropriate time is the heavy responsibility of teacher. In each session, the teacher should introduce new material related to the topic and the concept of new knowledge defines some criteria and standards for students to evaluate discussions. Criteria and standards are important in the learning process. Students must learn to how take new things and evaluate it based on their learned criteria to define the validity of something in discussion and debates.

Having an interactive learning is a part of social constructionism when people point out someone's mistake. We have to try to increase this number in order to have more successful e-learning model via active learning. When people want to know more about the logical reason of someone in believing something, they need to have broad information about the topic. So, assessment of their previous knowledge can help teacher to rearrange the context of the knowledge. The way that a discussion or debate goes on in collaborative learning is

very sensitive. The teacher must consider how students criticize opposite each other. The harsh or impolite critics may cause shyness in some students and push them to be secluded.

RQ1: How can we implement Information Security course based on constructivism principles on e-learning course of Information Security?	**Answer:** by adding some new design principles to the current principles of constructivism/constructionism such as students' role, teacher's role, reconstruction of knowledge content, and live group session attendance requirements we can improve effectiveness and students throughput. Also, students felt more comfortable and confidence to take final exam in 2013 in comparison with students in 2012.
Knowledge contribution:	**Answer**: Design e-learning model as an IT artifact for technical courses at University level by using Constructivism/Constructionism as kernel learning theory
Future work	**Answer:** need a technology to take online classes in virtual environment and assess students based on technical skills.

Table 11 the final conclusion

In the traditional local classes, the session is not recorded and students are required to attend. This makes it easy for the teacher to require students to be active. The teacher can simply ask the students questions, to see if they prepared for the lecture. The teacher can ask other questions to see if the students are learning, the material in the lecture.

In distance classes, Universities can choose between the following options.

1. Universities can inform students that the sessions are not recorded and that students are required to attend, via the Internet. Universities can require the students to be active, via a microphone. This option is similar to the traditional local class structure.

2. Universities do have another choice. If they wish, Universities can inform students that the sessions are recorded and that students have no obligation to attend. Universities can even allow students to attend who do not have microphones or who are not in an environment where they can participate via voice (perhaps at work, in a shared office).

It is only the 2nd option, which is very different from traditional local classes. The major problem with the 2nd option is that the sessions can lose their ability to require students to be active.

In the LTU course which we studied, there were 55 students who took the final examination. At one lecture, there were about 40 students online. Of those, only two students would agree to be active, via their microphone. LTU's choice in policy (no requirement to actively participate) has resulted in a lack of activeness by the students. The teacher then tried to pressure students to participate. This resulted in fewer students attending the live lectures. Instead, the students who wished to be passive just watched the recorded sessions.

One strategy by LTU to make students more active is to assign group assignments, which requires the students to pair up. However students often claim that it is difficult to work in groups, for various reasons. For example, students may be working full time. Most of the students working full time are attending classes via distance as opposed to locally. If the teachers make exceptions, this is another example where the class becomes more passive.

We discussed this InfoSec Program lack of requirement for students to attend live group sessions. Based on our input and feedback, LTU has agreed to change the InfoSec Program. The next version will state that some or all classes will require students to attend and be able to present via microphone, during most live group sessions. So we can see that LTU is in agreement with our finding.

12.1 Build theory to increase effectiveness in security distance courses

We designed a theory to construct a fundamental base for argumentation about legitimacy of active learning and further progress.

Based on Gregor (Gregor, S. 2007) there are eight components of design theory:

1. purpose and scope
2. Constructs
3. principles of form and function
4. artifact mutability
5. testable propositions
6. justificatory knowledge (kernel theories)
7. principles of implementation
8. an expository instantiation

Based on Gregor, our main goal is to design research as a knowledge-building work, instead of analyzing the structural nature of the knowledge or achieved results. We follow the steps of theory building to reach the conceptual framework of how to produce an e-learning model in order to increase active learning for distance education based on approved pedagogical kernel theory and to build our artifact. The subject of design theory for designing e-learning model based on constructivism is itself a methodology and it could be proposed to show architecture and abilities of the artifact. Gregor believed that designing a theory is happening in abstract world of human creations and can provides other abstract definitions such as models and algorithm. Instantiations of design theory would have a physical artifact in the real world (Gregor, S. 2007). We use this belief to provide a new frame work for our theory and use the relationships among IS/IT artifact to justify the abstraction of theory to build a model in which ICT and pedagogical approach are working smoothly. We assert that our theory is abstract and does not have any physical existence and just express as a set of words, diagrams ad pictures in order to support presentation aim and finally the gathering of these components can be a theory.

Type	Components of a design theory for new educational pedagogy artifact in virtualized environment based on Constructivism learning theory
The Purpose and scope of design	• Design an e-learning model which supports active learning, for both distance and on-campus students for courses which need hands-on exercises • Students must be active in the learning process to increase their ability to construct new knowledge, share new ideas through collaboration and interactive learning • To prepare students to become information security engineer • Motivate students to feel more comfortable and confidence to take final exam
construct	Based on our research question we want to • increase students throughput • increase effectiveness in learning by getting immediate feedback from other students and teacher • increase satisfaction in students from new IT artifact • increase performance of students in technical skills which is resulted in better mastery of subject in network domain • increase motivation in students to take final exam with more self-confident
Principles of Form and Function	• each student has to do hands-on exercises • students need to accept the attendance requirement for some courses • students need to be equipped by microphone and camera • students need to be active during session
Artifact mutability	• students' behavior effect on system • final assessment effect on system • students' satisfaction effect on system

Testable propositions	• we suppose to increase students' throughput by motivating the students to be more active during learning process and take final exam without any anxiety • we suppose to increase satisfaction in students by knowing their feedback to the new system through questionnaire and teacher's observation • we suppose to increase students' performance and effectiveness in technical skills by make them more active during session and technical hands-on exercises • we suppose to increase collaboration between students by using Constructivism principles to share their ideas with each other • we suppose that new model motivate students to take final exam easier
Justificatory knowledge	Data communication and security course was taught via active learning based on Constructivism as famous kernel theory of learning which was proposed by many constructivists such as Piagot, Vygotsky and Bruner. Constructivism learning theory is a famous learning theory which is applied by many universities especially for those who provide distance learning. Collaboration learning, student-based learning, learning through solving problems, assessments of knowledge, meaningful and deeper learning, immediate feedback are most famous features of this theory.
Principles of implementation	Principles of implementation e-learning model to increase active learning is keeping students in touch with technology and technical skills and push them to test vulnerabilities and ways of attacks to the following: • defending systems uses Metasploitable network layer vulnerabilities and UltimateLAMP – Web vulnerabilities • VM (virtual machine) images • VMWare Workstation or VMWare player

	• VMWare ESXI 5 • Learning management system (Moodle) • BackTrack 5R3 Linux OS • Microsoft Server 2008 R2 OS • Microsoft Windows 7 and 8
Expository instantiation	Apply our e-learning model on the MSc Info Sec technical course based on constructivist learning theory via active learning. Based on previous and related work in the literature part, those higher education which use Constructivism and ICT for learning were successful. This theory can be used by any other practitioners in future to implement physically.

Table 12 Components of a design theory for new educational pedagogy artifact according to Gregor, [(Gregor, S. 2007), (Iqbal, S. 2012, Päivärinta, T.)]

12.1.1 Who is audience of new theory?

The built theory can be used by both practitioners and higher education to increase active learning by producing e-learning model an artifact in IS scope even if it needs technological products or managerial intervention. The Swedish department of Defense supervisor has indicated that this thesis is of interest to them and that they are interested in further collaboration. We want to provide a solution for all types of audiences of this research in order to understand the nature and the source of problems in our case study. In fact, the interactions in both side of managerial and technological designs help to investigate more explicitly about a phenomenon.

12.2 Results in Relation to the Hands-on Lab Simulator

Without a simulator, to obtain the same hands-on lab results, we would have needed to use physical and/or virtualization. Based on our requirement for each student to have access to clients, servers, layer 2 switches and routers, the cost would be excessive. Also, the simulator came with several pre-programmed hands-on labs. Thus we had a much lower cost of implementation, as compared to creating all of the hands-on labs ourselves, with physical and/or virtual equipment.

12.3 Results in Relation to ADR

The main benefits we realized by using ADR, as opposed to the classic DR was that we were able to obtain feedback during the whole thesis process, as to if our finding were of practical use, in an actual University setting. I.E., ADR is much more closely associated with practical findings as opposed to DR, which is more appropriate for theoretical findings.

12.4 Future work and limitations:

Based on our literature review, analysis and discussion we got a conclusion that future work, to complete the current e-learning model, researchers must find a way that help students to make connections between useful and important taught material with their expected professional career. Also, we have to increase the level of motivation and stimulation in students to think more precisely about other's viewpoints.

Also, practitioners and researchers must find a solution to solve the problem of properly monitoring online practical examinations for distance students. If students are not properly monitored, the students' certificate of course completion becomes meaningless. At LTU, distance students are normally not monitored during the entire examination. Another work limitation for this research is time constraints that definitely had an effect on the results of our research. The course was officially 18 weeks, full time. In that time we needed to conduct all research activities and to report the results. This limited us to only perform the research on one group of students. Consequently, if we could have more time, the results would be more precise and accurate.

We recommend that LTU uses MOOC tools and mythologies, in order to improve LTU's courses, which are not actually MOOC courses.

13 Appendix

13.1 Survey, Attitudes towards Thinking and Learning

In this section we present questions which helped us better understand the students' attitudes towards thinking and learning. Here are the questions that we are used:

13.2 Survey, COLLES (Preferred and Actual)

In this online unit...	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
1 my learning focuses on issues that interest me.						
2 what I learn is important for my professional practice.						
3 I learn how to improve my professional practice.						
4 what I learn connects well with my professional practice.						

Reflective thinking

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
5 I think critically about how I learn.						
6 I think critically about my own ideas.						
7 I think critically about other students' ideas.						
8 I think critically about ideas in the readings.						

Interactivity

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
9 I explain my ideas to other students.						
10 I ask other students to explain their ideas.						
11 other students ask me to explain my ideas.						
12 other students respond to my ideas.						

Tutor support

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
13 the tutor stimulates my thinking.						
14 the tutor encourages me to participate.						
15 the tutor models good discourse.						
16 the tutor models critical self-reflection.						

Peer support

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
17 other students encourage my participation.						
18 other students praise my contribution.						
19 other students value my contribution.						
20 other students empathize with my struggle to learn.						

Interpretation

Responses	Not yet answered	Almost never	Seldom	Sometimes	Often	Almost always
In this online unit...						
21 I make good sense of other students' messages.						
22 other students make good sense of my messages.						
23 I make good sense of the tutor's messages.						
24 the tutor makes good sense of my messages.						

Table 13 Survey, COLLES (Preferred and Actual)

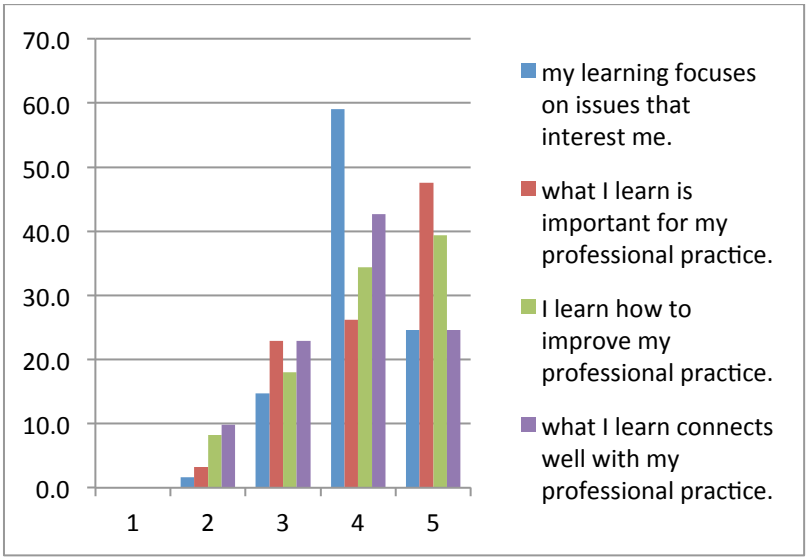
13.3 Evaluation of COLLES survey

The COLLES survey was a questionnaire used to assess the students' feedback and satisfaction, concerning the e-learning IT artifact.

We use the COLLES survey to provide an opportunity for students to give feedback on the new e-learning approach via active learning. Our learning process was based on social constructivism and COLLES which helps us to generate a measurement tool to measure students' perspectives, performance and satisfaction. We monitored the process of being reflective and collaborative in learning approach by asking students to fill out electronic surveys. We used the five point Likert scale to measure students' beliefs and satisfactions in active learning approach in virtual classes. We measured six independent factors in our survey among n=61 students. They are relevance, reflection, interactivity, tutor support, peer support and interactions.

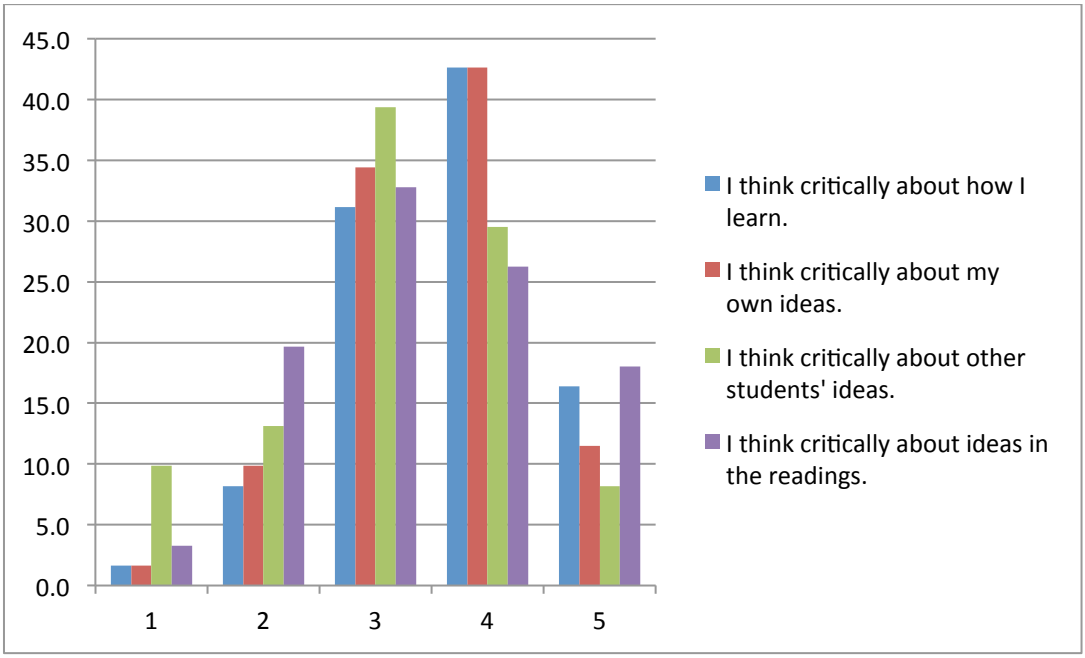
13.3.1 Relevance of course content to professional skills

Based on our evaluations, all students agreed that course material was focused on interesting and useful issues and should add value to their professional carrier and they could connect course material to the professional practices to some extent. Nearly 59% of students believed that in most cases course material focused on interesting issues and 47.5% of students claimed that the learned topics was almost always important for their professional skills. Nearly, 25% almost always and 43% often could successfully find the relationship between learned stuff and professional skills. Totally in the relevance part of our e-learning model we were successful, however, we should improve students' skills in order to make better connection between professional skills and course material which will be discussed in our conclusion section.



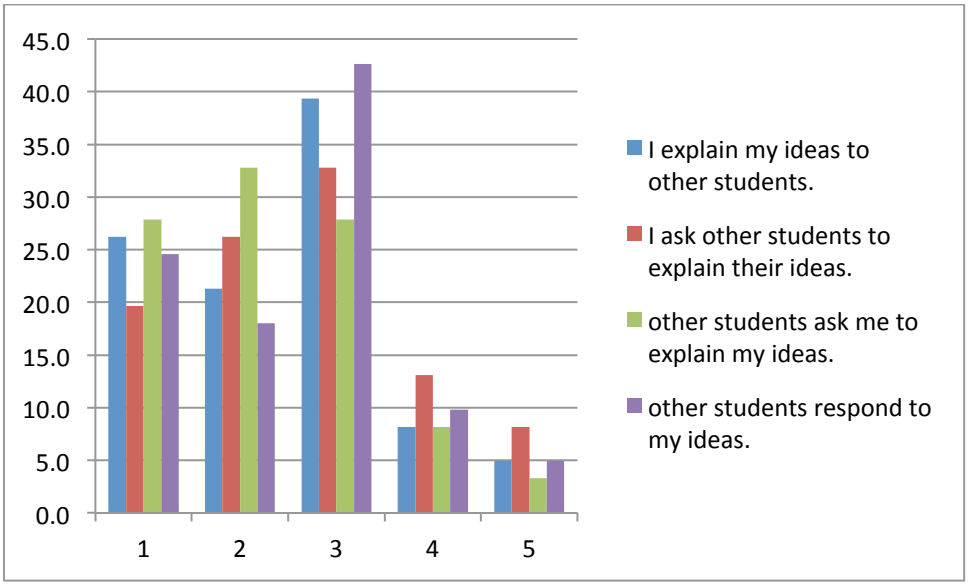
13.3.2 Increased ability of Reflection in students

Motivation in students is the most important factor to stimulate students being active in learning process. As much as they can think critically about what they learn, their own ideas and previous knowledge, other students' idea and course material, they get a much better understanding of what they have learned through an active learning process. Based on our analysis, there were only 8% of students who "always" and 29.5% of students "often" thought critically about other's ideas. The results show that when students are expressing their ideas to the others in social constructionism, less than 38% can get benefit out of discussion. However, 43% of students often think critically about how they learn and their own ideas. This shows that they think more often only about their own idea than others in collaborative process of learning. This means that social collaboration between peer is too weak or at least not in the perfect level of expectance. Nearly 33% of students think critically about new ideas in the reading material and it shows that they are not prepared well enough to think in a challengeable manner. Also, less than 30% of students think precisely and critically about what other students think and think about its reasoning.



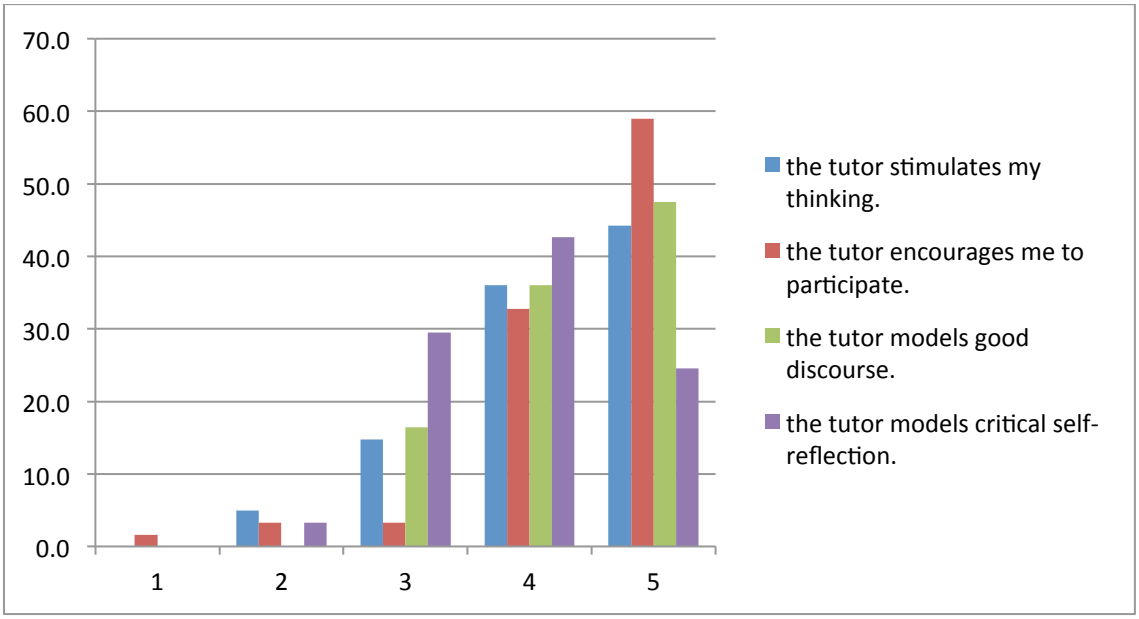
13.3.3 Level of interactively and engagement between and in rich educative dialogue

Based on our data evaluation, we have had the weakest level of interactivity of students with each other during the past semester. Based on data, less than 5% of students always explained their idea for others in a group and around 8% of students asked others to explain their ideas. Nearly, 26% of students claimed that they have never explained their ideas for other students and around 43% of students believed that they sometimes got respond from others to their ideas. Also, 28% of students never were asked to explain their ideas. During the session all students were often asked to provide feedback. So it appears that these 28% of students were the ones who never or almost never attended any group sessions. Only, 3% of students stated that they were asked to explain their idea for other peers in the group and around 43% of students claim that other students sometimes responded to their idea and 5 % of students almost always got respond about their ideas from others. The results show that, interactivity between students as one vital factor in active learning was too much weak in our approach which is controversial and will be discussed in conclusion part.



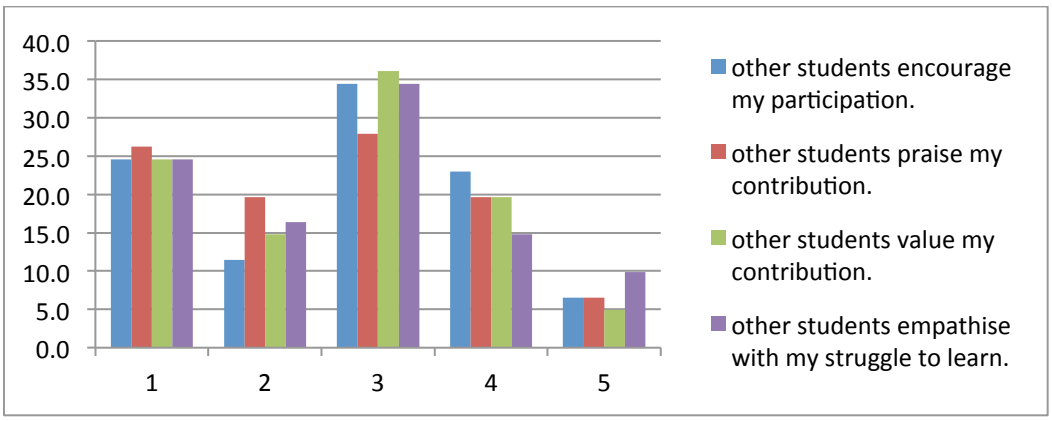
13.3.4 Tutor support to enable students to participate in active learning

In this section, we measure the tutor support from students' point of view and measured how well the tutor was successful to enable students in participation in active learning. Based on literature review, teachers in their constructivism and constructionism roles have a critical role to encourage and stimulate students to have a more active role in learning process. Our learning approach was very successful in this part. More than 44% of students believed that the tutor in both roles could always stimulate and motivate students to think in innovative ways. Moreover, 59% of students were always encouraged by during discussions and also 47% of students claimed that teacher always guided very qualified discussion during lectures. The results show that tutor support was strong enough in active learning for students.



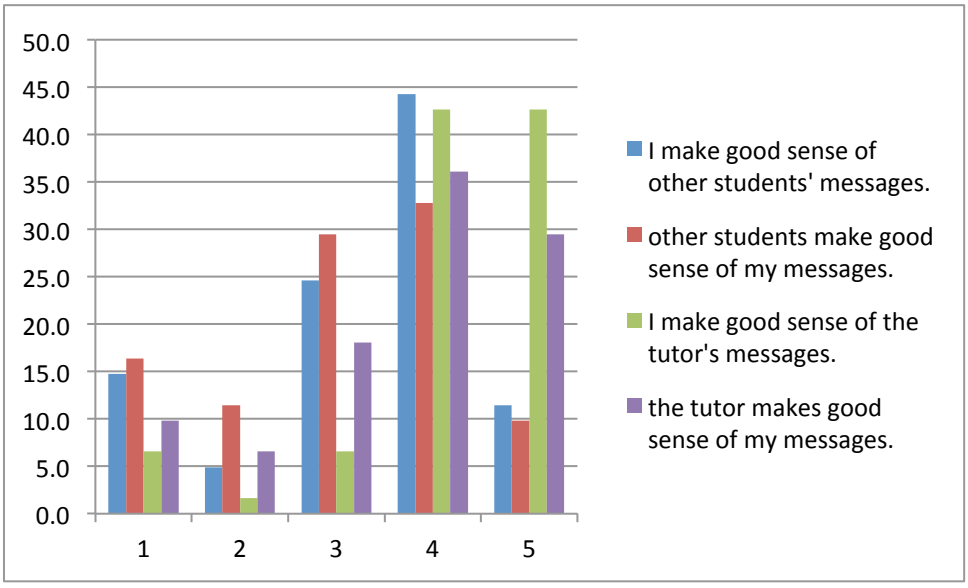
13.3.5 Peer support for each other

Based on data, students obtained the minimum support of each other to encourage, praise other's contribution, giving value to each other's contribution and appreciate each other to struggle to learn new things. Nearly, 34% of students claimed that they sometimes had peer support to learn new objects and 36% gave value to their contribution and 28% praise each other's contribution. Totally around 25% of students believed that they almost never got the support from each other. The result shows weak interactivity between students in active learning process.



13.3.6 Students and teacher's interpretation of each other

Since our education is distance based and we had virtual classrooms, in the last part of our survey, we investigated about the quality of understanding tutors and teachers from each other, in order to measure comprehensibility of course material and other comments. According to our literature review the level of understanding and misunderstanding of students and teachers have a direct effect on the quality of the active learning process. As students make better sense of the tutor's or other peers' messages there would be more collaboration, interaction and better learning in an active learning process. Fortunately, nearly 43% of students often and most always make good sense of tutor's messages and it shows rather highly comprehensibility of topics and the teacher's commands to the students. However, 11.5% of students make almost always good sense of other peer's message and 43% often made good sense of each other.



14 Tables

14.1 Structuring the review

We organize our literature review in a concept-centric manner. After we finished our literature review, we synthesize the literature by having discussion about identified concepts. Since tables are effective to convey the meaning we structured our concepts in tables. It will be easier for readers to understand our concepts in the topic areas.

The following list and table is structured by identification of key concepts, which are main factors in our research:

1. Yang,De Freitas,Sara Tassos Mikropoulos, Antonis Natsis
2. Ma,Dalgarno, Savin-Baden, Moreno,Rob Martens,Theo Bastiaens,and Paul A. Kirschner. Jara,Candelas, Torres,Dormido, Esquembre,Sara de Freitas, Genaro Rebolledo-Mendez,Fotis Liarokapis,George Magoulas and Alexandra Poulo vassilis
3. Billigmeier, G.M.
4. Tenenbaum,G. Ültanır,E. Yeager, Ben-Ari, Moreno, Dalgarno, Applefield,Vérillon,De Freitas, Sara Rob, Martens, Theo Bastiaens,Paul ,Kirschner Jara, Candelas, Torres, Dormido, Esquembre, Sara de Freitas, Genaro Rebolledo-Mendez, Fotis Liarokapis, George Magoulas, Alexandra Poulovassilis, De Freitas, Sara, Cocciolo
5. Shuang
6. Moreno, Gillet
7. Rob Martens, Theo Bastiaens, Paul A., Kirschner Tassos A., Mikropoulos, Antonis Natsis
8. Rob Martens, Theo Bastiaens, Paul, Kirschner. Jara, Candelas, Torres, Dormido, Esquembre Balta
9. Jara, Candelas, Torres,Dormido, Esquembre

Table 14 identified concepts in reviewed literature

concept / Author	Hands-on lab	virtual laboratories	Reconstruction of course content	constructivist/constructionist views	Change teacher in center	Using ICT based on systematic pedagogical approach	Active learning of students	Motivation of students	synchronous interactions
1	X								
2		X							
3			X						
4				X					
5					X				
6						X			
7							X		
8								X	
9									X

The next table summarizes similar projects and reasons of failures due to not having an explicit kernel learning theory such as constructivism or couldn't follow all principles of theory kernel theory:

Failures project	Reason of failure	They could be successful if they had ……
Tenenbaum, G. 2001	• lack of social interactions between students and teachers • lack of real-world scenarios to practice with • insufficient instructions of teaching in flexible environment	• interactivity between students • problem-based learning • reconstruction of course content based on pedagogical approach of teaching and learning
Keller and Ralf Naues (Keller, J. 2006), Fuh-Gwo Chen, Ruey-Maw Chen, and Jr-Shian (Chen, F.-G. 2011), Zackrisson and Svahnberg (Zackrisson, J. 2008)	• lack of attention to have a clear learning theory based on constructivism • teacher-based learning • role of student was passive • too much consideration to technology without reconstruction of pedagogical approach	• have a clear learning theory such as constructivism • discovery learning by students • active role of student • reconstruction of theoretical part also
Marten (Martens, R. 2007)	• his framework focused on technical possibilities and technology delivery and less on systematic design and evaluation of learning approach	• get feedback of students • have active learning

Fuh-Gwo Chen, Ruey-Maw Chen, and Jr-Shian	• they had even a part to build a curriculum for information security courses, but it was not specific pedagogical approach of learning based on student centered-based	• have a clear and pedagogic learning theory
Anisetti (Anisetti, M. 2007), James M. Hanson a & Kenneth E. (Hanson 2008)	• the main principles were not applied to change the active role of teacher and passive role of students • more technological consideration of the usage of ICT • teacher's role was stronger than students' role in learning process	• change the active role of teacher to mentor • change passive role of students to creator of knowledge • have both mentor and teacher's role for teacher position
Stepan Hubalovsky	• lack of concept of learning approach in educational methodology	• have clear principles of knowledge content for specific technical course

Table 15 Failure reasons in similar projects

The next table listed semi-successful projects which moved towards applying constructivism:

Semi-successful project	Reason of improvement
Yang, Z. 2007	• collaboration of students • satisfaction of students
Jing Ma and Jeffrey V. Nickerson in 2006	• including hands-on labs
Shakeel A. Khoja, Faisal Sana, Abid Karim, Arif Ali Rehman	• more active learning of students
Baturay (Baturay, M.H. 2010), Rovai (Rovai, A.P. 2004)	• effect on satisfaction and performance of students
Gillet, D in 2005	• collaborative learning
Fernando Alonso, Daniel Manrique, José M. Viñes	• considered psych-pedagogical prescriptions on teaching and learning
Moss (Moss, N. 2010), Neo (Neo, M. 2005), (Hamada, M. 2008), Delia Baskerville (Baskerville, D. 2012)	• increased satisfaction and performance of students • successful, collaborative • active role of students in learning process • implementation of hands-on experimentation • problem-based learning

Table 16 Semi-successful projects

In the final table, we found the most successful research in applying constructivism:

Project	Reason for success
Cocciolo in 2011	• active learning • collaborative teamwork • role of teacher as a facilitator and instructor

Table 17 the most successful research in applying constructivism

15 References

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