Learning Model Based System Development

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Abstract

This thesis presents the results of observations and analysis of students’ learning of model based system development from two related courses taught in the University of Oslo Norway and Florida Atlantic University USA. These two courses have been synchronized since 2012, and have been analyzed from 2015 to 2016. The data collections are done through interviews, observations, document analysis and a survey questionnaire. These two parallel courses with the same main course project were offered in 2015. After being updated and improved based on the initial analysis, the course was offered again in 2016 followed by a further in depth analysis of students’ learning experience. The aim of these two courses is providing students the competence of problem solving in modeling. The usage of models in the courses covers a full spectrum of modeling techniques, i.e., from initial business architecture models, to requirements models, system and software architecture and design models as a basis for implementation. Modeling languages that are used in these two courses include UML, BPMN, IFML and various DSLs. Our analyses and conclusions point out the need for a balance between individual and group learning in order to internalize knowledge, the need for a well-documented and working toolchain, and the importance of following models through execution.
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Hanieh Alibakhsh, March 2016
Chapter 1

Introduction

1.1 Why Learning Model Based System Development?

This thesis is focusing on the Learning of Model-Based System Development through an analysis of the experiences of two related courses at the University of Oslo and the Florida Atlantic University in 2015 and 2016. Learning model-based system development is becoming increasingly important as system development methodologies are using models to a greater extend and modeling as an intrinsic part of the software development process.

In the present research, the approaches related to the learning of model-based development would be analyzed. Model-based system development (MBSD) is a methodology based on the use of modeling within software engineering activities. Within software development, effectiveness and efficiency would be enhanced by applying the model-based system development method. This fact has been stated by various qualitative and quantitative research studies [30].

There has been massive growth in the development and use of modeling languages. Modeling can be applied in all phases from value-specific actions to the model-driven engineering realization phase. There are four essential facts involved when models are used for software development [30].

1. The complexity of the software systems is growing that is why it needs to be analyzed at various abstraction levels. These levels would be based on the relevant stakeholder profile, work objectives, and the development process phases.

2. In the contemporary world today, software’s have become a part of
an individuals’ life and they require continuous updates, innovation, and evolution of the present software.

3. In terms of job requests, the job market suffers from a continuous shortage of the skills related to software development.

4. Software development cannot be considered a standalone activity since it requires integration with non-developers like stakeholders, managers, customers and many others. These individuals require a sort of facilitation to understand the technical aspects of the software.

Considering the mentioned aspects it is a challenging task to teach modeling to the stakeholders.

This thesis presents the results of observations and analysis of students’ learning of model-based system development from two related courses taught in the University of Oslo Norway and Florida Atlantic University USA. These two courses have been synchronized since 2012, and have been analyzed in 2015 and 2016. The data collections are done through interviews, observations, document analysis, and a survey questionnaire. These two parallel courses with the same main course project were offered in 2015. After being updated and improved based on the initial analysis, the course was offered again in 2016 followed by a further in-depth analysis of students’ learning experience. The aim of these two courses is providing students the competence of problem-solving in modeling. The usage of models in the courses covers a full spectrum of modeling techniques, i.e., from initial business architecture models, to requirements models, system and software architecture and design models as a basis for implementation. Modeling languages that are used in these two courses include UML, BPMN, IFML and various DSLs. Our analyses and conclusions point out the need for a balance between individual and group learning in order to internalize knowledge, the need for a well-documented and working toolchain, and the importance of following models through to execution.

Firstly I start with a section on the learning process as a foundation for our analysis. Then introduces the educational context and further presents the qualitative analysis of the specific courses through the use of observations, interviews, document analysis and a questionnaire.

1.2 The area of research

In the present research, the MBSD (Model-based System Development) human factor aspects have been assessed. This includes learning about the models that place emphasis upon the system’s dynamic behavior and indicate the sequence of execution of the algorithm and actions, the system component collaborations as well as the internal state changes of the
Traditionally, coding was used to develop the realization phase. It was required to manage the habits of individuals, their resistance to change and motivate the learners to believe in the modeling even after considering that it is difficult and challenging [30].

The programmer’s productivity and product quality might reduce when a new tool or technique is to be learned. After the learning curve has been passed, the benefit can be attained eventually [30]. The use of model contains an essential discussion using Martin Fowler’s classification:

1. Sketches use models for the communication process and specification of the system view is partial.

2. Blueprints for models are used to attain a comprehensive and complete system specification.

3. The models are used as programs and not the code when the system is developed.

The model can be used in various ways by the software developers during the development process. For example, during the design discussion phase, sketches could be made of the models to help assist the discussion and later the proper models could be formed as a blueprint for the system. Lastly, these blueprints could be used to establish a system which is refined after using the appropriate code generation techniques to reduce the coding tasks [30].

The developed technological environment takes into account the business needs and software development process. These activities have been facilitated through modeling languages like Unified Modeling Language (UML) for software development and Business process model and notation (BPMN). These have not only be used in academics but also in the practical world.

1.3 My case study

Models have been used in many scientific contexts for simplifications and visualizations. Modeling is an incredible way for simplifications of reality in different perspectives, to get a better understanding of different concepts. Models have always been an essential tool in learning because it simplifies complex theories.
Students at the Software Requirements Engineering course (CEN6075) at Florida Atlantic University and the Model-Based System Development-course (INF5120) course at University of Oslo, have done the same project during the semesters in spring 2015 and spring 2016. Within the same requirements phase, modeling has been used by both groups with respect to the various aspects of business plans, requirements, and implementation. Various languages and methodologies have been used by the Florida and Oslo student in the second phase.

This study will investigate the learning process of students and see how the first modeling phase has affected the implementation phase, by keep focusing on the model based system development approach learning. As I believe that the level of understanding and learning in different phases can increase productivity and quality, and decrease the time of implementation.

1.4 Research questions

The three research questions are related to identify what is most important with respect to improve learning model-based system development at universities and institutions. To investigate how learning process can achieve better outcomes – in particular, related to the three areas of skills, understanding, and problem-solving.

1. Skill – What is important in order for the students to get good syntactic and semantic skills for MBSD? To which extent does learning background of students in modeling or/and programming effect the transmission of requirements specification into realization phase?

2. Understanding – What is important in order for the students to get good syntactic and semantic understanding of MBSD? Are there any dependencies between having a modeling background and a programming background among students for developing a structural and functional understanding of modeling languages?

3. Problem Solving – What is important in order for the students to get good syntactic and semantic problem-solving capabilities of MBSD? Is it an advantage to using more individual exercises versus group exercises to advance the learning of modeling techniques for each student?

Although research questions set focus toward describing characteristics of learning the concept, we will also try to be prescriptive in terms of further research and improvements in models education. Due to gather appropriate data, triangulation of methods has been chosen include interviews, observe- vacations, questionnaire, and document analysis.
1.5 Thesis outline

The outline for this thesis is presented here, to provide an overview of the contents and structure for readers.

Chapter 1 - Introduction

The introduction presents my personal and professional motivations for writing this thesis, a brief introductions to Model based system development followed by the research questions, and lastly this “reader’s guide”.

Chapter 2 - Learning Process

In this chapter, I will present the research field learning IT concepts. Further, I introduce the functional and structural understanding, syntax and semantic understanding and syntax and semantic problem-solving competence. The focus will lie on my interpretation of these concepts as I will use them later in the thesis in order to answer my research questions.

Chapter 3 - Learning Model Based System Development

This chapter is an introduction to model-driven architecture and thereby the scientific language within the domain. The introduction represents what the students in my case are supposed to learn in courses at the University of Oslo and Florida Atlantic University. Further a brief description of the project which has been used in courses to build up learners’ model-based system development understanding. The process and technologies for this project will be presented.

Chapter 4 - Research Methods and Empirical Setting

In 2015 and 2016 I gathered data for this thesis. In this chapter I describe the empirical setting, along with the methods used for collecting the data and how I used those methods. Then I will explain how I approached, selected and made sense of the data.

Chapter 5 - Interview

Here I will present the main achieved data from interviews. The interview objectives, interview guide, and related data from transcription be presented.
Chapter 6 - Questionnaire

Gathered data from questionnaire be presented in this chapter. The background which caused to have a questionnaire, objectives, questionnaire guide and responses will be discussed.

Chapter 7 - Observation and Document analysis

Observation results are presented in this chapter and a summary of result with respect to a learning model.

Students’ submitted projects and exam sheets are presented as well, together with the result of analyzing these documents.

Chapter 8 - Analysis and Discussion

The concluding remarks will provide the reader with an overview of how I approached this thesis and a review of the main findings according to the research questions.

Chapter 9 - Conclusion

The concluding chapter will provide the reader with an overview of how I approached this thesis and provide a summary of my main findings according to the research questions. Lastly I will present shortcomings and suggestions for future work.
Chapter 2

Learning Process

The research field, learning IT concepts will be presented here, and I will discuss the related concepts for further analysis.

2.1 Learning IT Concepts

Users of information technology (IT) need to constantly learn about new technologies and upgrade their knowledge. The learnability function would increase if the new flows are an extension of existing technology, or things learners are already aware of. This would correspondingly ensure a consistency in relation to the IT and related information aspects. For instance, in naming specific fields, the explanations should be evaluated since known terms would entail lesser clarifications. In redesigning business information systems, the terminology is an important aspect irrespective of whether users are working with paper forms or digital databases [24]. In learning process also could reduce the cognitive load which I discuss later in this chapter.

Learners have some competence when starting a learning process and they are more capable hopefully at the completion stages. This new competence would be used within the new IT tasks, and the impact of training related to the practical tasks is called transfer. Figure 2.1 illustrates the transferring process [24].
Figure 2.1: A transfer model shows the competence which is learned and transferred to practical settings

The subject or concept is significant in the learning process rather than the other elements including class and size [44]. A new IT concept for instance may appear confusing for beginners and to them even the most general principles and concepts are confusing. For instance new programmers need to learn and get an understanding of the programming principles and concepts to apply to different languages. Programming and modeling languages like other languages is a system that consists of symbols and grammars or rules to communicate with machines or a different environment. According to J. Shrager and D. Klahr in studying of developers learning a programming language their competence has been divided into syntactic, semantic and pragmatic competence [22].

Sein et al. (1998) [31] stated user competence in information systems area can be modeled in six steps. Learning functionalist’s and features of the software has been discussed by in the three lower steps of their model. The relation between technology and business have been discussed in the three upper steps of the model [31]. Furthermore Sein et al also added a learning-to learn step to their model [32].
Kaasbøll(2013) proposed three steps regarding learning an IT concept:

1. Skill
2. Understanding
3. Problem solving competence [24].

Figure 2.2: The complete cycle of learning IT understanding and skills

In Figure 2.2 the whole learning process is displayed.

According to this model navigation starts from an understanding, and further interpretation and reflection close the learning process. Further in this chapter skill, understanding and problem solving competence will be described more in detail.

2.1.1 The First Learning Level: Skill

Learning objectives have been described based on Bloom’s taxonomy which was suggested in the 1950s for improvement of cognitive competence [6]. Bloom’s taxonomy discussed the learning base on the levels 1) Repeat, 2) Explain 3) Apply, 4) Analyze and 5) Synthesize. Regarding skills acquisition Dreyfus and Dreyfus (1986) with 1) Novice, 2) Advanced beginner 3) Competent 4) Proficient and 5) Expert suggested a model [18]. The model distinguishes how learners’ skill improved over years of experience, something that modifies a skillful person behaviors as well. Bloom taxonomy more focused on theoretical subjects while the Dreyfus and Dreyfus concern practical skills learning process.

In learning computer science the challenge is the improvement of com-
patience from skills to understanding. This improvement is characterized by first being able to act, and therefore being able to represent the action. For instance, while learners were following the description several times, the learners could be able to tell an explanation of the action and say why action has been accomplished in this way [24].

Skills are the ability to fulfill a task, as understanding is in need of being able to express the action abstractly and being able to explain how and why we act like this. Understanding is knowing and recognizing the reasons for the action and mechanisms in a particular action. Since understanding is the result of studying and reading about the object, it calls textbook knowledge or know-why [24].

To execute the routine works by using technology, skill can be sufficient, however in order to improve the work or using some new technologies as demand, understanding can ease the transferring from the old environment to the newest one [10]. The main purpose of all training courses and learning materials for expertise in IT should be understanding in that specific IT concepts that learners work with [24].

According to the constructivist perspective, learning is a process where a new skill and understanding is related to previous knowledge [24]. For instance, if a learner sees a button in a new program, that has the same name as an already learned program; learner would immediately assume that it would perform the same action. This constructivist way of learning is why teachers are encouraged to map out the level of knowledge of the learners that forms the “platform” for their learning.

Learning happens in a sequence of steps where the first step is performed-ing an action and the second step is thinking about what one did. The second step triggers an understanding of ideas, concepts, principles etc. [24]. Further learners discover the relationship between the concepts and relating them to each other, which is called abstract conceptualization. There are several studies conducted on how one learns mathematics that support this abstract conceptualization [42]. As IT similar to math is both formal and abstract one can rightly assume that the process of learning IT happens in the same manner.

### 2.1.2 The Second Learning Level: Functional and Structural Understanding

According to Aharoni (2000) who showed that learners first deal with an operation and then acquired the experience. The learners, based on the achieved experience, could translate the effect of their action. They could refer to the starting and the result of their action but could not say anything about the phases in between [24]. This first understanding is called IT functional understanding.
At this stage of the learning process the learner can point out to the input and output of the operation but is unable to perform the action itself. This is because the learners’ first understanding consists of the input-process-output model. In the next process, the learners turned that action into a concept and could then convey that experience to other concepts.

IT Structural understanding is discussing the structure of the technology, while learning process of turning. The learning process of reflection leads the learner to the next phase which is IT structural understanding. This is the last accomplishment in the learning process when the learner can point to the idea as a thing of its own and use it when speaking about other objects [24].

However learners are not the same, while some users create sufficient understanding of their own task, slow learners are especially bad at doing the same task. Good learners came close to a functional understanding of a system operation when they tried to influence the system with unknown behavior patterns and no outside source of assistance [16]. The poor learners, on the other hand, came up with indicated degree of skill instead of understanding. As a result poor learners will have a major problem comprehending the next idea that is built upon they have not understood which in turn leads them to become even poorer learners [24].

When users of IT come across a new problem, they must deal with a new situation. This means that they have to learn something new. The better they are at understanding the better they are at solving the problems. To achieve problem-solving competencies in IT, the learner has to gain the ability to understand the issue or the problem. While one gains skills by using IT, one does not necessarily gain understanding. Understanding has more to do with being able to express and communicate about the subject matter [24].

2.1.3 The Third Learning Level: Problem solving competence

Learning to solve IT problems is like learning anything else, by doing it. Problem solving competence can improve by imitating others for example, whether it be a teacher or a peer user. Users must learn problem solving competence which entails learning the competence of exploration, experimentation and troubleshooting. Since competence is about learning, it is also called metacognitive competence [24].

The structural understanding could influence meta-cognition. One important element in meta-cognition is administrating one’s learning. For instance, teachers by teaching students how to take note or by illustrating good strategies through thinking aloud and by having students to do group work influence students’ meta-cognitive [36].
Good problem solvers tend to utilize a variety of strategies in solving problems. If one strategy does not work, they will try another one [41]. In a study by Eschenbrenner (2010) [13], a qualitative analysis was conducted to identify and categorized a set of characteristics of highly competent information systems users. "willingness to explore was found to be the most influential characteristics of highly IT system users" [13]. The capability to explore is therefore distinctive of IT problem-solving skills.

Having the ability of exploring the problems does not mean guarantee that those who possess this ability will use them. In a field study of user learning of software, exploring just for the sake of learning constitute the exception. This was true even when some of the users were computer scientists. The reason for this is that they found exploring unproductive or simply because they had much else to do otherwise [38].

Experimentation is a planned action of problem solving that starts with understanding level. Users have a hypothesis that they know that a system can do a certain action, what they want to explore is to see if it also can do other actions. If it can, how would it do that? This will make the user navigate, run the operation, interpret the result and compare it with the initial hypothesis. Experimentation, therefore, includes learning cycle process from understanding to understanding. Exploration and experimentation both contribute to enhancing IT skills and understanding of the related paradigms [24].

For instance, while using a functional prototype, the experimentation would be extensively helpful to learn the different concepts by learners. This would enable understating the capabilities of the prototype and could also encourage modifications in the system [24].

One main reason for failure in experimentation is due to insufficient functional or structural understanding [4]. In a study, two groups of users were given to different methods of learning. One group was given functional and structural models and the other group was given instruction. The result showed that the group with the functional and structural method of learning has developed better problem solving competence in doing the tasks that the instruction group [14]. This indicates that better understanding is needed for better experimentation.

The research competence is also applicable for solving IT problems, which entails executing different cycles of IT problem solving phases as in Figure2.3, Jens Kaasboll (2015) called it research cycle competence [24].
Figure 2.3: IT research cycle phases. Arrows denote actions to be carried out.

“The research cycles included building up a repertoire of suspicious information, selecting some of it to follow up, generating hypotheses about possible bugs, changing the value of a cell, and testing the outcome through manipulating some data.” [5]

2.2 Syntax, Semantic, Pragmatic

Aspects of syntax, semantics, and pragmatics contribute to the makeup of the representation system. Syntax relates to the representation system and semantics the relationship within the information and the associated domain, the pragmatic aspect relates to how the representation system is utilized [24].

Syntax defines the rules in how individual symbols could be combined together through a command sequence, on the lines of ensuring that specific symbols are followed through with numbers [24]. Semantics relates to a term and the meaning it conveys. For instance, ID cards are representative of the relationship between an individual and their name, and reflect the semantics associated with the name, according to Kaasboll. IT usage follows the same competence parameters associated with linguistics known as “pragmatics” [24].

Syntax and semantic competence could be explained in the context of skills, understanding, and problem solving competencies. The syntax could be considered in the context of models, directions and associated instructions related to perhaps IT learning processes. The learning
semantics could be considered in the context of the learning domain affiliated with structural models which could have been derived from data models [24].

2.2.1 Syntax understanding and problem solving competence

Specific rules enabling a better understanding of the modalities of representing single entities. How they can be combined constitute syntax. Correspondingly, the spelling and grammatical functions are part of the syntax associated with natural languages, while mathematical syntax is represented through numerical and statistical functions.

In learning modeling techniques, novices are more likely to learn process modeling than data or object modeling [20]. Process modeling entails various input-process-output units which are joined together through sequences and networks. However, data and object models are associated with capturing data structures. This is supportive of the fact that individuals are more susceptible to having a functional understanding over structural understanding vis-à-vis the given information [24].

Syntax skills relate to being able to syntactically enter the actual data. A functional understanding of the syntax necessitates the ability of the learner to infer the differences associated with input and output, before actually handling the data. A structural understanding of the syntax relates to the learner being able to perceive the concept in its own standing before subsequently referring to the same when detailing other aspects. Characterizing the output statistically and relating it to another enables a learner to have an understanding of structural syntax [24].

Syntactically problem-solving competence entail the ability to correct data with respect to the competencies associated with the rules of the system of representation. This could entail rechecking the data against the original [24].
Table 2.1 below gives an outline of competence levels within syntax according to Kaasboll.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Syntax skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Functional understanding and Structural understanding</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Research cycle competence and Corrections based on syntax rules</td>
</tr>
</tbody>
</table>

Table 2.1: Outline of syntax competence levels

Syntax competence is related to the skill and the ability to understand the representation system considered for expressing the information perceived. Semantic competence, therefore, relates to what is demonstrated, the information and the associated domain to representation system.

2.2.2 Semantic understanding and problem solving competence

Semantics relates to perceiving symbols, signs and related representation systems. It, therefore, considers how the various signs are linked together towards explaining the phenomenon under consideration. Oftentimes, this relationship can be quite complicated vis-à-vis the information available and the representative phenomenon under consideration [24].

The artistic phenomenon is an obvious example of the relationship between existing phenomenon and the perceived understanding of them. Authors or poets use words for their creation and mostly the primary idea of a novel or a poem has been reflected a lie, in the sense that the reality has no homologous with the provided novel or poem.

Nevertheless many readers have an imaginary world of the book which could actually correspond with the book’s essence, and not to the real world [24]. However abstract art or non figurative art are not representing any information, thus they are not informative art.

According to Kaasboll, likewise the music, they are consisting of notes and sounds. They do have a title or a name which has been defined by the musician, and also some specific instrument has been used to play the music. But all of this do not represent any reality but could be a delineation of an artist moments or feeling.

Semantic competence is being able to create information in a way that could present the reality. Semantic skill is transmission between the domain and the data, which means being able to detect a specific domain and record adequate and related data to that, or understand the data and be able to describe the domain from the data [24].
Semantic skills are required in the context of metaphors towards ensuring that the information being discussed is appropriately adjusted and is legible when considered in the actual context. Normally, individuals often use words with standard meanings in different variations and expect that the context in which they use the word would be sufficient to explain the use of the word, besides conveying the meaning intended by the speaker or the writer. Learning the domain of information which has been represented causes to learn and get a better understanding in semantic skill.

Functional and structural semantic understanding are two other concepts while functional semantic understanding refers to the ability of reasoning the way that domain has been presented in and the structural semantic understanding is the ability of analysis the domain information relationship, or the rules for using the information to present the domain [24].

In the learning, process navigation is a term which can be interpreted as searching. Finding appropriate information within a larger set for instance learning materials, online sources, and documentations. Semantic understanding encourages the navigation and semantical problem-solving competence is needed after finding the information.

Table 2.2 below summarizes competence levels within semantic[24].

<table>
<thead>
<tr>
<th>Skill</th>
<th>Semantic skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding</td>
<td>Functional understanding and Structural understanding</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Research cycle competence and converting to syntax problem solving</td>
</tr>
</tbody>
</table>

Table 2.2: Outline of semantic competence levels

Further, in this chapter, some learning methods will be presented.

2.3 Learning methods

Once the learning concept has been analyzed, the parts that emerge as complex to comprehend should be supplied with learning materials.

2.3.1 Functional and structural models

Functional models are learning material that aims at assisting in building understanding about the function. Functions with several steps, options and iterations need more overview that a simple drawing can give [24].
As long as functions do not include data structures, functional understanding would be the befitting level of understanding for concepts that are strictly functions. A function has an input position and an output position that is the outcome of the action [24]. For example, for the function of converging to pdf, the input position is a file of different type, the action is the conversion process, and the output position consists of the original file and the pdf file that looks like the original when it is printed out.

In some cases, however, a structural understanding is needed. For instance, programming an application may have a difficult data structure, and a user or developer may need to comprehend the structure to perform the work in a better way. In these cases, the user needs to have a structural understanding also.

Structural models may supplement functional models in order to build learners’ understanding through improving their reflection [24]. A structural model illustrates structures of the IT or structures of IT concepts.

For instance, when the user interface does not demonstrate the hidden components, structural models should be used to make them visible. A combination of language and graphics would be a better option of making the hidden features explicit since many of the hidden aspects are structural. When explaining what is going on inside a computer one should take into account users’ background, competence such as understanding of concepts, experience with working with software etc [24]. In order to not making the learning any more complicated one should try to ease the process by for instance make graphical representation simple.

2.3.2 User documentation

A combination of the structural and functional model along with instructions and directions enhances learning IT methods, which are often called “user documentation”. The user or learner documentation may come in paper or electronic documents or in the form of videos. User documents could appear also in the software which is called “inline help”. Later in this chapter, I will describe more about inline help.

A study conducted on the two learning methods, functional model versus instructions, showed that competence gained through functional model is more robust when it comes to transferring a newly learned competence hence to a new setting [40]. This study selected 20 novice users of a computer program where they were divided into two groups of ten users. One group was given functional models as help with five tasks that corresponded to functional models. The other group, similarly, was given five tasks with instruction as help. While the result of the group did not vary significantly, the study showed that when the groups were given two new tasks that differed from the methods of assistance, the group that was
given functional models performed the tasks better than the one that has instructions as for the method of assistance [40].

According to Robert P. Bostrom and Maung K. Sein [29] experiments, it was shown that coordinating structural models with learner’s visual ability would notably improve learning [29]. A sample of one hundred undergraduate students was selected. These were divided into two groups of high and low visual ability through a paper folding test. One group learning method enhanced by an abstract structural hierarchical model of folders and messages of an e-mail system. The other group used a model that illustrated the analogy between the computer structures and letters in paper-folders. The group with high visual ability learned more from the abstract model [29].

Regarding the other types of user documentations like the video, for instance, there are few guidelines to design better material. The content and examples for functional and structural models could be the same in documents and videos. People are better able to get and incorporate visual and oral when verbal explanations are given orally [24]. For example, when demonstrating a structural model in a video, the graphics should be the visual whilst the voice should speak about it [12]. There should also be a color marker or a sticker that points to the area that is being discussed at any given time. One should not commit the mistake of adding texts that further explains the graphics in the picture as this would overwhelm the visual capacity and not utilize our hearing [24].

During learning process trying to keep the cognitive load, low is important. For instance learning both the information and the whole phenomenon which being presented by the information make a high cognitive load and could slow down the learning process [24]. To have semantic skills and the connected technology skills separately as two subjects to learn cause lower cognitive and as a result better understanding. Chandler and Sweller, 1996 has claimed this [37].

So learners who prefer to inspect the manual, tutorial, documentations or other available learning materials first and then practicing them on a computer, later in task accomplishment are better than the learners who do the inspection and practicing simultaneously. According to Chandler and Sweller, 1996 it is accurate for written test as well [37].

Inline help and search engines can possibly provide a good method of learning. A broad explanation of people’s behavior when searching is found in [11]. Search is often needed, and when doing a search for help for troubleshooting the problem solving competence of correct observation is very useful. Copy pasting the error message when doing the search will most likely give an explanation. Understanding the explanation or the suggested solution is the next challenge for users.

While help seeking means asking other people for help, consulting
inline help has traditionally been viewed as information search. Both asking others for help and information search is a metacognitive skill that is useful in learning [24]. The advantage of asking others for help is that the user would get an answer that is tailored to user’s need after the user has communicated what it wants.

Those being asked, on the other hand, may not have the answer and have to do a search by for the answer in line or have to do a search on IT department’s database of the user request. This means asking for help would mean a search via a third party. Searching the web using the exact error message or the problem well described is most likely to yield the desired response very quickly due to the massive amount of information on the web. Also searching inline in the software may lead to coming across archived emails or communication that helpers have had with previous users having the same problem.

2.3.3 Community of practice enhances learning

Lim et al. 1997, [23] stated that talking during the learning process when the learners are working with the computers which are necessary to achieve the initial skill to get familiar with the concepts and tools, provides better understanding. He suggests pair learning which means having two learners at each computer, while one is working with the system like clicking and operating tasks and the other one ask questions, make comments, check the documentation and etc.

The pairs could discuss and explain about the methodologies and functionality of the software. They achieve better results in exercises that contain new concepts [23]. Operation in pairs is brought from computer science education which is called “pair programming” McDowell et al. 2006, addressed that pair programming is more efficient for learners than individual learning [3].

Wenger (1998) [45] considers a community of practice (CoP) entailing three crucial elements related to domain, community, and practice. The identity of the CoP is considered within a shared domain of interest with corresponding competencies within the domain. CoP members acknowledge their collective competence and share their knowledge.

Secondly, CoP members constitute a community by engaging jointly in interactions and associated discussions through working together and information sharing. Relationships are also built which facilitate free information flows, although CoP members do not necessarily work together regularly [45].

The third element within CoPs relates to practice, in how the meaning and the structure of the activities are considered. Sharing practices enable
practitioners in having a shared resource base in terms of tools, experiences and in how they deal with recurring issues. Thus, groups of supermarket workers could constitute a CoP when pooling their resources in dealing with goods and clients since they interact, discuss and help all around while manipulating the process using sales and pricing tools [45].

In this chapter, the learning process has been presented and in next chapter, the IT concept, Model Based System Development (MBSD) which is the focus of this thesis will be presented.
Chapter 3

Learning Model Based System Development

In this chapter, I will present MBSD methodology, the courses contents, and projects and how the learning process theories with respect to the previous chapter will be applied in this thesis.

3.1 Modelling

It is impossible for the human mind to stay away from visualization and modeling could be perceived as a type of visualization. This is why models have become essential in the field of technology, like engineering and computer science, similar to other sciences [30]. The past few years have seen a steady improvement in modeling education, with various international conventions carried out on this subject by researchers from all over the world.

There are several scientific contexts in which models have been used for visualizations and simplifications, for example, in the Bohr model of the atom in chemistry or physics, or in the billiard ball model [30]. One of the best ways of simplifying reality in various perspectives is modeling, which helps in obtaining an improved comprehension of a variety of notions. Models have played a vital role in learning as complex theories can be simplified.

Modeling has been applied in the development process, investigate, validate, document and elaborate on the product characteristics in the stages of requirement specification [30]. Models can have different objectives: they can have descriptive objectives (i.e. to explain the reality of a system or a context), prescriptive objectives (i.e. to recognize the scope and details of the problem to find a solution), or they can explain the
implementation of the system [30]. There are certain ideas or models that are taken into consideration by developers, engineers, and designers for the objective system.

Due to model-based system development, there is an improvement in efficiency and usefulness of software development by using models, and this is evident in several qualitative and quantitative studies [39].

3.2 Model Driven Development

Model-driven Architecture (MDA) can be considered as a kind of model-driven development (MDD) which signifies an approach towards system engineering in which models are employed in comprehending, design, producing, deploying, running, maintaining and altering software systems [25]. With the help of model transformation tools and services, the various models are aligned to make certain that there is consistency between the various refinement levels [25]. There are three main objectives of MDA, which are portability, interoperability, and reusability. Since the previous few years, MDA has been employed in certain practical case studies in the industry, even at the enterprise level [17].

In this regard, model-driven development signifies a business-driven approach for software systems development that is the most abstraction level of modeling which has been referred to a computation independent model (CIM) which explains the context and needs of the business [25]. There are modifications in the CIM refined to a platform independent model (PIM), which explains the services and interfaces that should be offered by the software systems to the business, regardless of software technology platforms [25].

There are additional enhancements in the PIM to convert it into a platform specific model (PSM) which explains the realization of the software systems in terms of the selected software technology platforms. Apart from the business-driven approach, a model-driven framework should also explain how the legacy systems can be combined and modernized as per the latest business requirements [25].

Figure 2.1 below shows the three levels of modeling, computation-independent (CIM), platform-independent (PIM), and platform-specific (PSM) models.
Figure 3.1: "Modeling abstraction codified in MDA: computation-independent (CIM), platform-independent (PIM), and platform-specific (PSM) models" [30].

The objective of model-driven development is to employ the appropriate group of models and modeling approaches, supported by relevant tools, so as to provide adequate assistance for specification, design, and analysis of the systems. It is considered at the start of the MDA that UML is being used for modeling, even though various sections of UML are appropriate for various levels. Frequently, an adaptation of UML is also required, particularly for detailing the PSM [25], and the last few years the use of domain-specific languages has increased in popularity.

3.2.1 Models

The modeling technique for the purpose of choosing would concentrate on the ability of the method to signify the model at the desired degree of depth and detail [25]. To choose a technique that would permit the inclusion of relevant information, it is vital to take into account the content of the conceptual models. The background and experience of the participant and user of the models should be linked to the complexity of the conceptual model, otherwise, it is possible that there would be misrepresentations in
the system requirements specifications or the basic notions of the system may be misunderstood by stakeholders and this would create issues in the fulfillment of the system [25].

System requirements include a specification of how a system should behave in order to fulfill the stakeholder needs. It needs to be determined what is required from the software, and explain this to the different stakeholders and team members. This should be then used to propel the development and testing of the latest system” [8]. Various models can be used for a variety of levels with respect to the model-based system development. The subsequent Table 2.1 briefly explains certain models that can be employed for Business Architecture and CIM.

| Business Process Model and Notation (BPMN) | Business Process Model and Notation (BPMN) is an approach of business process modeling that presents a graphical illustration for denoting business processes in a Business Process Diagram (BPD). This is grounded on a flowcharting method that has close similarities to activity diagrams from Unified Modelling Language (UML). BPMN seeks to provide support for business process management, for technical as well as business users, and this is done by offering a notation that is insightful for business users and at the same time signifies intricate process semantics [47]. |
| Business Model Canvas | The Business Model Canvas refers to a strategic management and lean startup template for producing new or recording existing business models. It is basically a visual chart whose elements explain the business or product’s value proposition, customers, infrastructure, channels, revenue streams and finances. It helps the companies in creating consistency in their activities by showing possible tradeoffs [46]. |
| Service design | Service design is a kind of conceptual design that consists of activities like planning and organizing people, communication, infrastructure and materials of a service, with the aim of enhancing its quality and the collaboration between the service provider and customers. Service design techniques mainly look for developing back and front office of services to make them user-friendly, competitive and appropriate for the customers, while at the same time become sustainable for the service provider [49]. |
### User Story

In the field of software development and product management, user story refers to an explanation which includes one or more sentences in the routine or business language of the system user or end user that explains what a user does or has to do to fulfill his/her job duties. Agile software development techniques are used alongside user stories to explain the functions of a business system and to bring about requirements management [52].

### Unified Modeling Language (UML)

In the software engineering field, modeling language offers a standard means of visualizing the system’s design. It mainly depends on the notations of the object-oriented software engineering (OOSE) and the object modeling technique (OMT), and these have been combined into one language. The UML provides a means of visualizing the architectural blueprints of the system through a diagram [50].

### Use Case Diagram

This is a presentation of a user’s interaction with the system, where the association between the user and various use cases where the user is involved is shown. In a case diagram, various users of a system can be recognized, and this is frequently also going to have other kinds of diagrams [51].

### Class Diagram

In the field of software engineering, a class diagram that is part of the Unified Modelling Language represents a static structure diagram that explains the structure of a system by depicting the system’s classes, their features, functions (or techniques), and the associations amongst objects. The class diagram is the foundation of object-oriented modeling, and is employed for general conceptual modeling of the systematics of the application, and also for extensive modeling which converts the models into programming code [48].

| Table 3.1: Selected models which could be applied for Business Architecture and CIM |

### 3.2.2 Mappings

A mapping is included in the description of the correspondences amongst the elements of two distinct models. There can be mappings for all types of models. Mapping identification can be described as weaving, explaining simple correspondences amongst meta-model elements; and restrictions,
explaining the specifications for model transformations [30].

Mapping provides rules and algorithms for converting all kinds in the meta-model of the PIM languages into all kinds in the PSM languages [30]. This is depicted in Figure 2.2: PIM mapping into PSM is considered as a transformation that is explained between the platform independent metamodel and the platform dependent meta-model.

![Figure 3.2: "Pictorial representation of the transformation implementing a mapping between PIM and PSM levels" [30]](image)

Transformations can be used to implement mapping amongst various models or modeling levels. A conceptual requirement can be offered by mapping for executing the transformation amongst various levels of modeling. The apparent goal is to automate the mapping execution to a high extent, therefore preventing expensive manual transformations [30].

### 3.3 IFML as a platform independent modeling language

#### 3.3.1 Why using Interaction Flow Modeling Language (IFML)?

A common issue expected in the software industry by everyone every time they start producing software application is in user interaction and user interfaces [9]. In the development process, most of the effort is expended on developing system infrastructure and system architecture.
When the system reaches the designing of the interaction between people and systems the process can be high costs and there can be huge challenges in having proper user interfaces and user experiences.

A new model based technique that has been developed for designing user interfaces is the Interaction Flow Modelling Language (IFML). This method is not just a manual way of coding by programmers in user interface technologies; rather, it also has a level of abstraction that includes modeling. Three years back, IFML approved by the Object Management Group (OMG), which is the standardization division for Unified Modeling Language (UML). It has been suggested that there should be a standard for explaining user interfaces and user interaction in such a way that production and communications could be enhanced [9].

The user interface is one of the areas during software development process where communication issues amongst business requirements and IT implementation can be so extensive that a large gap between the business field and the IT field would be identified [9]. It is mainly for this reason that entirely different languages are spoken by these worlds. There are entirely different terminologies in the business world, in addition to distinct objectives and distinct ways of determining the quality of outcomes compared to the IT world. Hence, those things that are perceived to be obvious in the business world may not be as obvious from the IT point of view, and vice versa [9].

The objective of interaction flow modeling language is to decrease the communication gap between the two worlds by establishing a mutual ground or language that can be shared by these two worlds for comprehending each other in a more effective and productive manner [9].

IFML mainly concentrates on a particular issue that encompasses the problem of user interface design. This includes IT organizations need to reach an agreement regarding the business objectives and needs to meet certain requirements in the software [9].

Interaction flow modeling language is not merely a symbolic language, rather, it has been converted into an executable model that can turn out to be a more absorbing outlook towards IFML [9].

### 3.3.2 Interaction flow modeling language

IFML has the ability to explain what is presented in the user interface, its contents and the different interaction options that can be used there. In addition, it explains the navigation paths that a user can follow in the user interface [9]. See Figure 3.3.

The user interface is also permitted by the IFML to attach to the business
logic and persistence and database storage layer within the system [9]. Similarly, this not the explanation of just the UI, but it attaches, connects and interacts with several other perspectives in the system design.

Figure 3.3: IFML Objectives

Figure 2.4 shows the key elements. The container element is the first one which signifies an empty box, a screen or page in a mobile application, or the window for a desktop application. Within the container, it is possible to explain the content of user interface by adding the view components which signify the widgets [9].

The visual elements can be developed in the page, or on the application screen and on the view components, with the events being indicated. The circle symbol can denote the events which explain the fact that on the element, user events can take place. Following this event, developers may indicate navigation flows that are the potential paths which may be followed by the user by integrating one or more user interactions [9].
Using a simple example, the overall structure of user interface is going to be explained subsequently, as well as some content.

Figure 3.4 shows a container that is the same as that in the fire-frame, and within the container, it is possible to describe the content. Using these components, the artists can be listed, and detailed description of the artist can be given by another component. Within IFML, dynamicity of interaction is more visible. It is possible to enable a particular user interaction event in an artist list, which is the event of clicking on an element. This arrow indicates that when this event occurs, the user moves across this path and will be able to observe the detailed attributes of the chosen artist. Towards the end, the developer can easily see view container, view component and event to explain the dynamicity of interaction [9].
In model-driven development automatic transformation of models has also been taken into account. It is because of models transformation into certain codes that the software is able to run. It is asserted in the model-driven development approach that developers integrate modeling with model transformation such that they are able to run software from the models [30].

Modeling is the foundation of the value input for designing the application. Since the model is quite abstract and platform independent, the source code that has been generated could principally encompass various kinds of technology platforms [30]. There can be multiple source codes, because using the same model, developers can produce the source code for web interface or web applications, in addition to the source code for mobile applications or for the desktop management part of the application.

Developers are able to explain the user interface, and also bind it to the business. The user navigation and user behavior are depicted in Figure. For example, it can be seen that there is a screen or container that includes one widget, which is a list of albums. Through content management system, users are able to create, remove or update content. After adding an event to the album list, and then possibly clicking the event, the user is able to delete that particular album from the database. The developer has specified a delete event.
The navigation flow does not directly take the user to another screen, rather, the navigation stops in actions that can be signified by a hexagon symbol in IFML. This is a invocation of a business logic activity on data that carries out certain behaviour. Therefore, by selecting a particular album, the user actually caused the album to get deleted from the database, then be redirected to the album list. The album list would now present an updated list of albums.

It is possible to model other similar behaviors. For instance, in e-commerce websites, users usually get a shopping cart page, from where they can click on check out. At checkout, there are one or more steps more for payment of orders. The system normally has the customer information and the credit card payment information to carry out the payment. After payment execution, they would possibly receive a confirmation message.
If this process is completely designed with IFML, then it becomes a little more complex, however, it could also become more self-explanatory and complete. Developers can add what is presented in each step of the navigation to explain the interaction [9]. The shopping cart is depicted in Figure 3.7, where we can see a list of products that have been added by the customer to the cart. When the customer presses the “check out” button, they can pay for that list.

After this, users are redirected to the process of payment. If customer data is registered in the database, the form to include customer information, and the payment (credit card) information and then submit this information would be the final step of the process.

Figure 3.7: Online payment
Further IFML can be used to develop complete websites or mobile applications by modeling like this. This means that modeling can be more effective and can be used again in other systems. For example, a clear explanation of the user interaction for the checkout process has been provided. The IFML allows the developers to develop their own explanation of the checkout process by explaining the whole module. In fact, the whole process is somehow covered in a black box as can be seen in the Figure 3.8.

![Figure 3.8: Payment execution](image)

The design can become more understandable, and simple. With this kind of specification, the checkout process becomes more simple and reusable with a lot of coherency in the user interface.

### 3.4 SenseIt, The Project

In this section I will present briefly the “SenseIT” project, which has been developed by students at the University of Oslo and Florida Atlantic University. The framework and the architecture of the project will be presented. The description will not be in-depth in technical aspect but rather an overview for readers to get a better understanding of the project which has been used during the semester for learning model based system development approach.

The main project of the courses in Spring 2015, at the University of Oslo and Florida Atlantic University, was related to the business architecture and service offering, respectively to system architecture and software
solution, for “SenseIt” a new imaginary start-up company [7]. The main project had been handed out in two separate assignments.

SenseIt intends to offer services on smartphone application and web based application for people who are exposed to the sun. The idea is to implement support for a wearable Ultraviolet (UV) light sensor, that can communicate the measured values of Ultraviolet A (UVA) and Ultraviolet B (UVB) light via Bluetooth 4.0. The UV [2] index is average of UVA and UVB values which have been obtained by the sensor and has been applied to the below formula

\[ \text{UVI} = \frac{(\text{UVA} \times 1.1 + \text{UVB} \times 1.9)}{25} \] [19]

The UVA and UVB values will be sent to the application for further processing and services. Amazon Elastic Compute Cloud (Amazon EC2) as web service has been chosen for data retrieving.

Bluetooth devices using Bluetooth 4.0, have two ways of implementations, either Bluetooth Smart Ready or Bluetooth Smart devices (SensApp framework, 2014). For this purpose, we planned to use a small and inexpensive SunBit UV sensor which is Bluetooth Smart devices and has support for Bluetooth Low Energy (BLE). Due to time limitations I cannot give an explanation about the SunBit sensor and UV radiation measurement.

![SunBit UV sensor](image1.png)

Figure 3.9: SunBit UV sensor

Figure 3.9 shows the latest version of the Bluetooth technology, which introduced Bluetooth Low Energy (BLE).
3.4.1 Business Architecture and Requirements Models

In the second assignment, the focus was on a model-based realization of the Senselt App specification from the first assignment, using Interaction Flow Modeling Language (IFML) for Mobile. The model requirements flow for the first phase was as below [7]:

Agile planning and enactment, Business Model Canvas and Value Proposition Canvas, Service Experiences, BPMN processes (Business level, System level), UML information model (Class Diagram), User stories, Use cases, UI mockups and non-functional requirements.

By enhancing different tools and frameworks students had defined desired requirements specifications in the first assignment. Figure 3.10 shows UML class model of “Group 1” which has been submitted as a final delivery [33].

![Figure 3.10: UML Class model diagram for Senselt mobile application](image)

3.4.2 Model-based realization from the business architecture and requirements models

The second assignment was the model-based realization of SenseIT application. The mobile application has been developed by using the Interaction Flow Model Language (IFML) and Webratio mobile platform, and the web application has been developed by using web development languages such as HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, and PHP: Hypertext Preprocessor.
The back-end project has been in charge of connecting to a provided Web Service (hosted by amazon) with some example data of Ultraviolet (UV) measurements. In addition, the project was provided a REST Web Service interface for the front-end application to interact with the data stored. The project was cloud based when executed, so it could be accessed from anywhere through REST application programming interface (API) calls.

The front-end project was in charge of providing the functionality designed by the students. The data from the back-end could be accessed through REST API requests and has represented as a domain model internally. Then this model was be exposed to the users through views, which would provide the required functionality.

Base on the specifications from the previous assignment, students have created a Scrum plan and executed the essential issues for final submission. Mostly the early sprints objectives were to retrieve data values from the MongoDB server by sending HTTP request, realization of login functionality and display data on the applications. Further the students have implemented different functionality based on their requirements specifications. The figure below shows the implementation of login function by IFML.
Figure 3.11: Login/Logout by IFML

Figure 3.12 shows the architecture of the mobile application.
Figure 3.12: SenseIt mobile application architecture

The architecture could present the difficulty level of the main project which has been delivered successfully by students.

3.5 Learning context

The Model-Based System Development course has been held for master’s degree students and doctoral researchers since spring 2004. The course has been taught for more than a decade, and during those years, the subjects have always been the latest technologies. In the INF5120 course the main focus is object modeling by use of Unified Modeling Language (UML) in architecture and development of software. Recently, a collaboration between INF5120 (the Model-Based System Development course) at the University of Oslo and CEN6075 (Software Requirements Engineering) at Florida Atlantic University made the case more interesting for this study. The course on Requirements Engineering has been given since 2008.

In CEN6075 the analysis of requirements and specifications be presented and various methods to support these analysis principles. Problem analysis, modeling, requirements documentation, and prototyping have been addressed as well. The course has been founded on the theory of software engineering as represented in the recent work of Software Engineering Method and Theory community (SEMAT).

To summarize learning competence, a three-level model of competence building, the following Table is presented and will be used further in analysis and discussion.
<table>
<thead>
<tr>
<th>Learning competence</th>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill (The student is able to use tools and methods on given examples)</td>
<td>The student is able to use tools and methods—according to correct modeling language notations.</td>
<td>The student is able to use tools and methods—according to the creation of meaningful models with good quality.</td>
</tr>
<tr>
<td>Understanding (Able to explain the principles in tools and methods)</td>
<td>The student is able to explain the principles in tools and methods according to correct modeling language notations from a Functional (How models work) and structural (How models are built-up) perspective.</td>
<td>The student is able to explain the principles in tools and methods—related to the creation of meaningful models with good quality, from a Functional (How models work) and structural (How models are built-up) perspective.</td>
</tr>
<tr>
<td>Problem solving competence (Able to apply the tools and methods to new problems)</td>
<td>The student is able to apply tools and methods—according to correct modeling language notations—related to new problems.</td>
<td>The student is able to apply tools and methods—according to the creation of new meaningful models with good quality—related to real world problems</td>
</tr>
</tbody>
</table>

Table 3.2: Learning competence model

Learning IT skills such as the spreadsheet programs like Calc and Excel was the main focus area which has been discussed in "Developing digital competence - learning, teaching and supporting the use of information technology". Jens Kaasboll (2015) [24] evaluated the learners while the context is related to the usage of ICT tools. While in this study I will apply the learning competencies with respect to learning to model in MBSD. In next chapter, the research methodologies during this study will be discussed.
Chapter 4

Research Methods and Empirical Setting

In this chapter, I describe my case study and the research methods which have been applied. Further, I present the process to prepare the primary data for analysis.

4.1 Empirical Setting

This thesis was started at SINTEF (Norwegian: Stiftelsen for industriell og teknisk forskning), the largest independent research organization in Scandinavia [43] in spring 2015. At the same time, I was working as a teaching/research assistant at the University of Oslo and had a great opportunity to participate closely with students in the Model-Based System Development course (INF5120). Simultaneously, by holding workshops and presentations for students, I conducted three passive observations during the semester at the University of Oslo, of group work of students while they were studying, discussing, and finding the solutions for the main real project during a course.

In spring 2015, 15 students with different backgrounds had participated in and taken the final exam in INF5120, and 14 students with different backgrounds had taken the exam in CEN6075. All students developed the same project with the same methodology (model-based system development), by using different technologies in the realization phase. The project was all to be done in a group consisting of three to four students.

The INF5120 course is structured into three areas (two common areas) with the following modeling techniques:

1. Business Architecture (Common)– Presenting Models for Enterprise
Architecture (TOGAF and UPDM) with Business Architecture and System/Software Architecture connected through Requirements Models as the context. Business Architecture focus with Business Model Canvas (XX) and Value Proposition Canvas (YY), Service Design with Smaply and diagrams for Personas, Relationships models and service journey models, service models to Value Networks and VDML, Domain models with UML Class diagrams, Business Process models with BPMN, Requirements models with User stories and UML Use cases/templates and UI Mockups with Balsamiq. Modeling methods are presented through the OMG Essence standard software engineering modeling approach.

2. Software Architecture and Design (Common) with user interaction modeling using IFML (Interaction Flow Modeling Language) and supporting WebRatio web and mobile platforms for web and app development. Support for executable BPMN models.

2.1 Model Driven Engineering and system architecture – only for MDE course - with Eclipse EMF and Sirius for the development of domain specific language editors and model-to-model and model-to-text/code transformations. Further modeling techniques for software architecture and design, like System and Software Architecture with UML 2.0 Composite diagrams and UML collaboration diagrams including SoaML.

2.2 Requirements Engineering – only for RE course – with modeling through additional requirements modeling techniques on goal-oriented requirements and further on non-functional requirements.

INF5120 and CEN6075 courses are structured through lectures, teaching assistant lab hours, individual exercises/projects, main project and student presentations - as a one-semester graduate course.

The different learning perspectives discussed in the learning models chapter are supported through the courses. The skill development is supported through the active use of modeling tools. The functional understanding is supported by the tool user documents, while the structural understanding is supported through the lectures and learning materials with theoretical foundations, examples and lab hours. The problem solving competence is achieved through the work with a real case as a main project and teaching assistance. The table below explains the learning methods.
I conducted three passive observations in Oslo and eight interviews with students from Oslo and Florida. All students were informed about the research purposes, that they will remain anonymous and the provided information will be used appropriately. They signed the consent form before the interviews. After the interviews, interview transcripts, reports, and exam sheets of all students were analyzed with respect to the existing theoretical perspective about learning IT concepts. As a result, some improvement suggestions were presented to course structures for better learning outcomes. Then, in spring 2016, questionnaires were distributed to the current students.

### 4.2 Research Paradigm

This thesis is a qualitative study with the underlying interpretive paradigm. An interpretive study claims that access to reality can be a social construct such as language, consciousness and shared meaning [34].

Case study as a methodology provides a way of approaching research questions in a real-life scenario and digging into the concept, context, meanings, and experiences of a specific case at a specific time. In this research, “Learning Model-Based System Development,” all these aspects are crucial since the learning phenomenon is composed of the concepts, thoughts, backgrounds, and feelings of individuals. In the same manner, case studies focus on theorists, actors, and local meaning within specific cases [35].

---

<table>
<thead>
<tr>
<th>Learning materials</th>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill</td>
<td>Lectures, BA tools, SA tools, MDE tools, RE tools—</td>
<td>Teaching by showing relevant examples, demonstrations, video tutorials, and exercises</td>
</tr>
<tr>
<td></td>
<td>with user guide and teaching assistance guidance</td>
<td></td>
</tr>
<tr>
<td>Understanding</td>
<td>Functional and structural understanding by using user guides, lectures, books, and articles about modeling language symbols</td>
<td>Functional and structural understanding by using user guide, examples, lectures, books, articles included structural models about relationship within modeling language</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Guidance, inline help and feedback on practical exercises in lab hours</td>
<td>Guidance, inline help and feedback on the main project</td>
</tr>
</tbody>
</table>

Table 4.1: Learning methods
Furthermore, the concept which is aimed to be learned, the learner’s background, and how they affect the learning process have been discussed in this study. My case study aspects could not be compatible with other paradigms, especially positivism, which assumes that knowledge is an object that exists “out there,” rather than as something that is socially constructed[34]. Positivism considers knowledge as something independent of the researcher. Also criticizing conflicts and contradictions in my case study were not the aims of the study, which is the goal of critical research [34], therefore critical perspective could not be appropriate for this research either.

In this study, there has not been any theory tested; but research questions which I tried to answer with respect to theoretical perspectives. According to Stake (2005) [35], “The qualitative researchers are interested in the diversity of perception, even the multiple realities within which people live. Triangulation helps to identify different realities”. Use and collecting of a variety of empirical materials in qualitative research is necessitate of the studied [35]. So I have chosen different methods to include interview, observation, questionnaire, and document analysis to answering my research questions.

4.3 Data Gathering methods

4.3.1 Interview

In this study, as the most common methods of data collection in case studies, semi-structured interviews with audio recordings was my main data gathering method. Interweaving the students and reviewing other existing relevant litterateurs, helped to investigate the case more in depth to enhance the analysis and findings.

The plan was to have interviews at the end of the course when students had submitted the final project. Between May 13 and May 30, 2015, eight semi-structured interviews were conducted. Among the eight interviewees, there were four students from INF5120, the Model-Based System Development course at the University of Oslo, and four students from CEN6075, the Software Requirements Engineering course at Florida Atlantic University.

Unfortunately, due to limitations of time and budget, I was not able to travel to Florida during the semester. So interviews with students from Florida were conducted by using Skype and GO TO Meeting, online services which caused some challenges. Some of the challenges are discussed as below.

Except for some emails before the interviews, there was no meeting or
observation session with students of Florida Atlantic University. During the interview I could understand how the earlier contact can affect the interview flow, therefore interviews with Norwegian students were more informal than the interviews with students from Florida.

All students were sent an invitation by email to participate in an interview. I explained the subject of the thesis and the purpose of the interviews as well. Before the interviews, the students from Oslo were informed about the purpose and what the interview questions would be about, and they signed the consent form and delivered them to me. For the students from Florida, they received the consent form by email after they declared their acceptance of the invitation, and then I scheduled an on-line interview with them.

You can see the consent form in appendix chapter.

The interview duration was planned to be 30 minutes. The table below shows the duration of each interview and which course the student was from:

<table>
<thead>
<tr>
<th>No.</th>
<th>Course</th>
<th>Duration (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INF5120</td>
<td>36:31</td>
</tr>
<tr>
<td>2</td>
<td>INF5120</td>
<td>34:02</td>
</tr>
<tr>
<td>3</td>
<td>INF5120</td>
<td>1:09:06</td>
</tr>
<tr>
<td>4</td>
<td>INF5120</td>
<td>46:49</td>
</tr>
<tr>
<td>5</td>
<td>CEN6075</td>
<td>30:18</td>
</tr>
<tr>
<td>6</td>
<td>CEN6075</td>
<td>27:55</td>
</tr>
<tr>
<td>7</td>
<td>CEN6075</td>
<td>33:05</td>
</tr>
<tr>
<td>8</td>
<td>CEN6075</td>
<td>32:18</td>
</tr>
</tbody>
</table>

Table 4.2: Interviews duration

Most of the interview durations were as scheduled, though, for those who were more interested in the model-based system development topic, the interview took more than 30 minutes—up to 69 minutes. You can see one of the interview transcriptions in appendix chapter.

As mentioned, the interviews were conducted at the end of the semester, which caused some challenges for me and for the students to schedule an interview. The students had a very hectic time regarding the assignments deliveries and the final exam. There was no possibility for me to choose the interviewees, but fortunately, the participants had different backgrounds, which was important for the subject of the thesis. Altogether, I have written 82 pages of interview transcripts, which provided me with data to answer my research questions.

Interviews were fully transcribed in order to be used later in the
analysis as an essential source of data. Audio recording has kept the answers unbiased, as the statements have not been affected by how the researcher remembers or perceives the answers, and can be directly quoted.

4.3.2 Questionnaire

A provided semi-structured questionnaire for students had been designed to gain learners feedback on the courses in 2016. One of the reason that I have chosen questionnaire in 2016 was the accessibility to my case study community [28]. I have been away from the students during a semester and other methods like observation and interview could be a challenge by considering the situation. Questionnaires were handed out to all students from INF5120 and CEN6075 within the masters and Ph.D. degrees. 16 students completed the questionnaires, which had 18 questions. The outcomes were mostly quantitative data, which have been used in combination with the other data.

Questionnaire as a data collection method has challenges which I tried to consider while creating a questionnaire. For instance, it is sufficient to be concrete and clear in defending the questions and answers, to be sure that participants will get accurate understanding from the questions and will provide an appropriate response.

For handing out the questionnaires and analyzing the data, I used the Google Forms online survey as a tool. Later, in "Questionnaire" chapter I will represent the questions and responses.

4.3.3 Observation

Three passive observations were conducted on April 6, 14, and 20, 2015 at University of Oslo. On April 6, a week after handing out the first part of the project as an assignment 1 to students, I held a presentation to clarify the project and requirements specification and at the same time, we discussed the tools, technologies which should be used and students’ questions. All learning materials, such as documents, video tutorials, and sample projects. During workshops and presentations before the final delivery, I never discussed the thesis with students, and as a teaching assistant, I attempted to be very friendly and supportive. So in this way, I tried to conduct observations in naturally occurring settings.

In addition, after the presentation, I was always available via email to answer questions. Many of students sent me their problems, and through discussion with them, I got some impressions of their individual understanding’s level. The shortage of time for learning and solving advanced-level project in the subject was also a challenge for both students,
the course instructor, and assistants.

On April 14 and 20, 2015, I had two workshops with all groups of students. Each group consisted of four students with different backgrounds. During the workshops in two sessions, I simulated being a group member and worked with them on the same computer. I had a discussion with all group members about different issues related to the assignment. Yet there were always ones who were more active and motivated than others. Even though the plan was to guide an interactive discussion between all members, the active ones were always the leaders.

4.3.4 Document Analysis

Regarding the document analysis, learning materials, reports from groups of students, and exam sheets were analyzed and evaluated to gain a better understanding of the empirical setting of the case.

During a course, different learning materials were presented to the students: books, on-line sources, presentations, slides, and video tutorials. Based on Jens Kaasboll theories [24] which have been presented earlier in chapter two, and feedback from students all learning materials and teaching methods have been analyzed. Evaluation of the learning materials and teaching methods could enhance analysis and discussion of learners’ exams results, learners understanding and learners’ problem solving competence. Documents which have been used were mostly group reports, which might affect my analysis for individual cases, and the exam sheets are all anonymous which provided me an overview for students’ individual understanding. Thus individual cases were more challenging.

Students submitted two assignments, and at the end of the course, they have submitted the main project. Finlay, they took a written exam. An in-depth evaluation of assignments, the main project and exam results was done by scoring all parts of the assignments and exams questions.

The writing exam consisted of three questions. Question 1 is composed of five sections, while question 2 and 3 has three sections. All particular sections independently have been scored between 1-100 percentages and then calculating the total grade. All questions were scaled first and later the whole exam percentage was evaluated based on each question’s score.

4.3.5 Ethical Considerations

Norwegian regulations on collecting and managing personal information, entitled “Personopplysningsloven” (Personopplysningsloven 2000) [27] [15], were followed during data collection. Subsequent to Section 8 of this law, those who signed and submitted written consent form were
interviewed, and the participants were informed about the terms and conditions under which the data will be used, as defined in Section 19 [15]. According to Section 11, only data which are relevant to my thesis were collected.

During this research period, and in the interview transcripts data, all the participants have represented anonymously. Identifying information of all interviewees has been and will be protected securely, and will be deleted upon termination of this study.

4.4 Data Analysis

The analysis in terms of interpretive methodology is a process which requires thinking creatively in-depth about all descriptions and theories to construct, represent and contextualize the findings actively [28]. The researchers’ interpretation, evaluation of findings, reliability, and validity of results and at the end generalization of the hypothesis are significant phases in this process.

During the coding process of interview transcriptions, I used initially open coding [21], to develop categories. Of main challenges was to prevent looking for relations too early during coding, as it could lead to prejugdement later in the analysis [28]. The coding was an iterative process, and I repeated that until no more labels could be set.

During the coding process, the situation where the interviews were conducted is as important as the participants [35], so I tried to pay attention to the settings as well. Such as the place, time with respect to the course schedule and exam time, and how could I connect with interviewees during the interview. Being open-minded during the analysis process is also essential which has been always a challenge for researchers. Regardless, I tried to be open-minded during the process, the coding process was influenced anyway because of the interpretive approach of this study. The gathered data from interviews and questionnaires will be presented and discussed in next chapters.
Chapter 5

Interview

Interviewee’s responses are presented in this chapter and will be discussed later in analysis and discussion.

5.1 Interview - 2015 - FAU CEN6075 - UiO INF5120

After the realization phase and final submission of the projects in 2015, eight semi-structured interviews have been conducted. Students with diverse background have participated in the interviews.

The main objectives for the interview were to know more about the learner’s background and experiences, their understanding of model-based system development and learners learning methods during the courses. According to argumentation which has been reviewed and presented in chapter 2, the interview objectives illuminate the research questions which I will analyze and answer in chapter 9.

Below you can see a part of my interview guide which has been developed based on the literature review from an earlier phase in my research.

- Do have you any background in software architecture and system development?

- How would you rate your own level of software engineering/software architecture/modeling? 1-10

- If you have any experience with different methodologies or programming languages: How would you compare the methodology and the technologies you have used in another project and the methodology and technologies you have used in this course?
- Could you explain shortly how do you usually learn/practice new IT skills?

- How many hours per week have you used for this course/project? Could you specify the hours that you have used for each phase on your projects? (1-5 at CEN6075, and 1-2 at INF5120)

- During the project what have you worked with to gain a better understanding? Lectures, documents, tutorials, videos, discussion, your teaching assistant? Which one was more useful?

- Do have any suggestion to improve the instructions sheets and the learning material?

- What is the level of your functional and structural understanding of the project? 1-10

- During the project when problems occur, could you explain how did you solve the problem?

- Were any of these models/diagrams used/related to any implementation work – how? Business model canvas, MyServiceFellow, Personas Stakeholder maps - Journey maps, BPMN, UML Information model, User stories, Use cases w/without template, UI Mockups, Nonfunctional requirements and Scrum

- For realization part – were any of the requirements models above used as input?

- What do you think about the teaching methods?

- Do you think that the course was useful? Do you manage later to work with the methodology and technologies in more complex software projects?

- What do you think about the difficulty level of the course? 1-10
5.2 Responses

5.2.1 Background of Learners

The table 5.1 below shows the background of interviewees.

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Background</th>
</tr>
</thead>
</table>
| 1           | "... I started doing my bachelor in the college of Oslo in the field computer science, programming so I finished. It took three years and then I started here at the University of Oslo to do my Masters in the field which is called programming and network."
| 2           | "... doing the Ph.D. in the Geographic Information Systems in health and I am going to use the Malawian system for health sector. This particular semester I took one of the model courses which is a model-based system development. ... My first degree was in the Computer Science and mostly it was about programming and the software engineering issues. Then my Master's on the GIS and Drug Logistics. I did some more programming in GIS system development for Drug Logistics."
| 3           | "... What I did in Spain was Computer Engineering, which is more or less computer science or software engineering because in Spain we call things differently than in other places. So it's a four years degree. And my Ph.D. studies are about model based system development. I'm working with a company that is producing induction cups."
| 4           | "I'm doing my Masters in Network and System Administration from the University of Oslo and I'm taking this course as an elective course, model-based System Development. I have Bachelor in Computer System Engineering and I studied some languages courses like C, C++ and OOPs, but they were just introductory courses, not specialized courses, so in my final year I selected specialized courses in networks."
| 5           | "I've had some programming experience since high school for a while. I graduated from FAU in December with my bachelor's, but I had actually started, well I started working in the actual field about maybe two years before that, so more less like three years ago, I started working.... I started doing programming in the medical field, basically writing different software in .Net environment, VB .Net, C."
“I am working as a software programmer since fourteen years so I have been involved in a complete development life cycle of custom solutions as well as implementing products. ... In my current position we work with minimal requirements from the customers so we have not even a page, we will have five or six lines of requirements that the customer wants and then we basically interpret it and based on our personal experience, we develop it and then we implement it. And then most of the time, I don’t know whether we are lucky or it’s experienced, we are pretty close to what customer wants.”

“I am graduated student from Florida Atlantic University in main major computer science. I am Linux system administrator, have been working with Linux, past of the years. More software architecture I don’t really do that outside of the school I just do some scripting and development as part of my job but that’s it for now.”

“I graduated from FAU in computer science and I am working as system developer since 7 years ago. Have been working with many different software projects. The company is a IT consultant company and we are developing and customizing different software for different use and purpose.”

Table 5.1: Interviewees background 2015

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Functional Understanding</th>
<th>Structural Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

Most of the learners have a programming background and have worked as software engineer for some years. Moreover, they have studied and worked in different field such as design and development of information systems and some of them have worked in network and administration field. Learners’ background will be considered later as one of the essential factors which might affect Learners’ skill and understanding of MBSD concept. For instance, when discussing learner’s improvement during the courses the learner’s background will be considered individually as well.

5.2.2 Understanding Level

Tables 5.2 Below shows the answer of students in interviews when I asked them to rate their functional understanding, which is their initial level of understanding of the project and structural understanding, which refers to their understanding of technologies structure has been used in the project. In the rating, one represented the minimum level of understanding and ten represented a solid understanding.
According to the interviews transcriptions in 2015 the total average of students’ functional and structural understanding was 7.49 at the end of the course, while the same in 2016 at the end of the courses was 8.14. The difference between averages shows that the improvement suggestions which were executed in 2016 was useful with respect to students learning outcomes in MBSD.

### 5.2.3 Problem Solving

The interview was included a question about learners’ problem solving methods.

The students’ responses in interviews were presented in the following table 5.3. Where I asked them about their problem solving methods during the courses.

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Problem Solving method during system development process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>So we were provided with video tutorials and we started to work on it, we encounter some errors so I went back to the video, wrote everything.</td>
</tr>
<tr>
<td>2</td>
<td>When I had a problem on the particular task, the first thing, I checked on the net if there are some suggestions, I went to the forums on the specific problem and in some cases, I had some suggestions where I tried and the problem was solved. If the forums could not answer, I try to consult my group members so I send that problem to the group members. If somebody got some suggestions we communicate it. And then if the group failed then we would go to the assistance providers for suggestions.</td>
</tr>
</tbody>
</table>

Table 5.2: Interviewees level of understanding 2015
I need to open the developer console and check the messages that are going to the server and back to check the errors, and to me, it’s not possible to get, to hide, I mean we are modeling, not coding, if I try to contact to a web service, and the web service is not answering, and the JavaScript or the – not JavaScript, the output console of the browser gives me an error message, that’s code because it’s an error message rise from the code and it’s saying something like, “null exception, you’ll point the exception, whatever, whatever.” But it’s something that I want to be aware of because otherwise, it’s not possible to fix the problems. We try to follow, to see what was happening. And also with the example projects, the example projects were really good.

First of all, I try to look at it myself, I go through Google and read the tutorials regarding that and consult other people if they are facing the problem because we might find a lot of forums where people are posting their problems and their solutions. If I don’t find anything on Google regarding my problem then I go to my other group fellow or other class fellows and if they are also unable to solve my problem or to explain to me then I try to contact with the teacher assistant and then obviously the problem is solved because teacher assistants are really built here to help us.

When I come to problem, like when I’m programming, basically I just look online, Google, StackOverflow, see if the problem has already been solved, and you know just basically read until I find the solution and, if I don’t find it which is not very often, then I will look for an alternative way to do it.

The mix of lectures, basically looking at the lectures and then also trying to Google stuff, go and find some materials on this topic which we are looking at and then come back again and make changes and then again keep revising and that’s how I did it.

Just by researching them. For instance where the point server that we had was very limited originally when one of our group members wanted to use our for charge and that stopped and so we just used some PHP classes to handle the charge the but then if it should that, so pretty many researchers to solve that and at the end it worked out.

So base on the problem, unfortunately, I have a bad habit of forcing something or trying to make it work and I spent hours trying to make it work before I switched, but I eventually don’t switch and that was one issue that came across with the result, by switching to the super format.

Table 5.3: Interviewees problem solving competence 2015

According to transcriptions 75 percentage of students, trying to search the problem on the internet for their first attempt, and 37.5 percentage
referring back to the course materials. Among other problem-solving competence, 50 percentage of students discussing the problem within their groups, in the case of being unsuccessful to find the solution from the forums or related communities on the internet. Generating various hypotheses regarding solving the problem and evaluating them in a systematic manner made the students more successful in solving the problems [24]. However improving the hypotheses need an appropriate understanding of the concept and proper problem-solving competence is essential too. Later I will analyze the student’s problem-solving competence by considering their understanding level in MBSD.

5.2.4 Data Transformation

During the interviews, I asked the students if any of the requirement specifications model were used/related to any implementation work and how? -the answers could show both understanding of the learners and the usefulness of the models in practice. In table 5.4 below the keywords of students description with respect to each model has been showed.

<table>
<thead>
<tr>
<th>Model</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>5</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business model canvas</td>
<td>not useful</td>
<td>very helpful</td>
<td>overall picture of the app</td>
<td>useful</td>
<td>was definitely useful</td>
<td>helpful</td>
<td>it did help a little bit</td>
<td>based on customer segment</td>
</tr>
<tr>
<td>My Service Fellow</td>
<td>not useful</td>
<td>useful</td>
<td>good to try</td>
<td>not used</td>
<td>not used</td>
<td>helpful</td>
<td>I do not remember</td>
<td>useful</td>
</tr>
<tr>
<td>Personas</td>
<td>we tried</td>
<td>very easy</td>
<td>modify the app</td>
<td>not used</td>
<td>not used</td>
<td>easy</td>
<td>figure out the site</td>
<td>helpful</td>
</tr>
<tr>
<td>Stakeholder maps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journey maps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPMN</td>
<td>a process model</td>
<td>was definitely related</td>
<td>It is just a model</td>
<td>I don’t understand that</td>
<td>I don’t understand that</td>
<td>helpful</td>
<td>not useful</td>
<td>helpful</td>
</tr>
<tr>
<td>Model</td>
<td>Usefulness</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UML</td>
<td>useful</td>
<td>was definitely related to totally thinking in code</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User stories</td>
<td>helpful</td>
<td>was important</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use Cases</td>
<td>helpful</td>
<td>was very important</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UI Mockups</td>
<td>useful</td>
<td>was definitely useful</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-functional</td>
<td>did it,</td>
<td>not used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrum</td>
<td>useful</td>
<td>was interesting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 5.4: Usefulness of specification models/techniques, 2015**

Most of the students had a problem with BPMN understanding and therefore they were not sure that how it could help the realization phase. Among all models UML, user stories, use cases, and user interaction mockups have been perceived so useful in terms of clarification.
and implementation of the project. During system development, data transmission between different phases requires syntax and semantic understanding of concepts and also syntax and semantic problem-solving competence might help learners to solve the problems more easily. How many students understanding effected on the data transmission process from requirement specifications to realization phase will be analyzed in chapter 8 later.

Further learners mentioned that time for implementation part was short and models helped them to get a common idea of the project between the team members. Due to solve this problem, the related assignment handed out earlier in the courses in 2016, and the result of that will be analyzed based on students’ responses to the questionnaire in the same year.

5.3 Summary

Thus to summarize the interviews outcome, learning competence, a three level model of competence building can be useful to understand. As illustrated in Table below and will be used further in analysis and discussion.

<table>
<thead>
<tr>
<th>Interviews</th>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill</td>
<td>Attending the Lectures, learning to work with BA/SA/MDE/RE tools with user guide and teaching assistance guidance</td>
<td>Attending workshops related to tools demonstrations, video tutorials and exercises and working by relevant simple examples</td>
</tr>
<tr>
<td>Understanding</td>
<td>Functional and structural understanding by attending the lectures, reviewing provided learning materials and exercises</td>
<td>Functional and structural understanding by attending the lectures, reviewing provided learning materials, examples, working with provided exercises and structural models</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Related Inline help regarding models, reviewing provided learning materials like presentations notes, teacher and assistance’s feedback on practical exercises in lab hours</td>
<td>Discussion with group, IFML inline help provided by Web radio, feedback on the main project, and repeating the same steps until the problem gets solved</td>
</tr>
</tbody>
</table>

Table 5.5: Interviews results
The average of students understanding shows that IFML is a complex language to learn in the context of developing mobile and/or web applications. The Interviews on skill shows that the tool video tutorials with example templates work well, and when talking about problem solving competence the interviews transcriptions show different groups were working differently with respect to how they divided work and responsibilities.

Furthermore, the responses to the questionnaire from students in 2016 will be presented in next chapter. In 2016 I asked students about their experiences with individual and group work.
Chapter 6

Questionnaire

In this chapter questionnaire and students responses will be presented and more specifically the courses recommendations which were carried out in 2016 will be discussed.

6.1 Questionnaire - 2016 - FAU CEN6075 - UiO INF5120

Due to time limitations at the end of the spring 2016 semester, open semi-structured questionnaires were chosen and provided for students. To gather experiences from the courses FAU CEN6075 Requirements Engineering and UiO INF5120 Model Based system development, sharing much of the same techniques and tools, and a common project for the spring of 2016 the anonymous questionnaire has been handed out between students. The objective was both to get a better understanding of learning experiences in using models in system development, and in getting input for improvement for the courses. Below you can see some of the questions from a total of 15 structured, semi-structured and open questions.
Your Background
In which field do you have more background/experience in?

- Design and User Experience
- Language and Communication
- Nano-electronics and Robotics
- Programming and Network
- Network and Administration
- Modeling and Data Analysis
- Innovation and Entrepreneurship
- Other

Background
If other please describe:

Your answer

Figure 6.1: Your Background

System Development understanding at the start of the course
How would you rate your own level of understanding in requirements specification modeling and realisation methods/technologies in system development at the start of the course?

1 2 3 4 5 6 7 8 9 10
Have No Idea what are you talking about! Solid Understanding

System Development Understanding at the end of the course

1 2 3 4 5 6 7 8 9 10
Have No Idea of what you are talking about Solid Understanding

System Development Understanding checkpoint
What are the benefits of using models in system development?

Your answer

Figure 6.2: System development Understanding
For some specific objects, I have designed both open and close questions which gave me the opportunity to analyze the responses more precise. These two different types of questions were useful to prevent bias in data which could happen by students’ misconception from the questions. Figure 6.2, 6.3 and 6.4 show both open and close questions regarding students understanding. In provided questionnaire in 2016, I ask more generally about the understanding level than the functional or structural understanding. The reason for that was a challenge which I faced during the interviews in 2015. Students mostly had difficulty to understand, functional and structural understanding. Thus the comparison between the gathered data here might include bias.

Figure 6.3: Modeling Understanding
Figure 6.4: Programming Understanding

Programming Understanding at the start of the course
How would you rate your own level of understanding in Programming?

1 2 3 4 5 6 7 8 9 10

Have No Idea what are you talking about!

Solid Understanding

Programming Understanding at the end of the course

1 2 3 4 5 6 7 8 9 10

Have No Idea of what you are talking about

Solid Understanding

Programming Understanding checkpoint
What is a constructor? (1 Line)

Your answer

Figure 6.4: Programming Understanding
To which degree did you find the specification models/techniques useful for the implementation part with IFML/WebRatio (from 1 less to 5 most)

<table>
<thead>
<tr>
<th>Model Type</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrum</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>Business Model Canvas</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>User stories</td>
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<td>Use cases</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>Smaply - Personas</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Smaply - Stakeholder maps</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>Smaply - Service Journeys</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>Balsamiq Mock Ups</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>UML Class/domain models</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>BPMN Process models</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>Non functional requirements</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

Figure 6.5: Specification models usefulness

---

**Course structure**

In respect to learning process during the course what you think about the course schedule and individual/group assignments? Why?

*Your answer*

---

**Learning method**

Which one was more effective for you learning and understanding, individual or group assignment? Why?

*Your answer*

---

Figure 6.6: Feedback on course structure

63
6.2 Responses

Below you can see some responses to the questionnaire:

6.2.1 Background of Learners

Different students with diverse background have replied the questionnaires in 2016. The chart below shows students’ background.

From total 16 responses, 75 percentages of students had programming and network background and 6.2 percentages of students had modeling background which might be significant in the analysis of their understanding and problem-solving competence during the courses. Having a scientific background in the learning subject cause lower cognitive load, as I mentioned in chapter 2 and as a result better understanding and problem-solving competence. For instance, early start with executable models in the beginning of the courses to get early and incremental experience with practical modeling related to programming might also enhance learners’ background.

6.2.2 Understanding Level

Among questions, I asked learners to rate their modeling and programming understanding before and after the courses. Some checkpoint questions have been designed as well which were supportive of approving or rejecting the student’s responses. The following charts show the responses. You can see the system development understanding of students at the start of the course in figure 6.8 below.
Students rated their level of understanding from 0 to 10, where 0 be scaled as “I have no idea what are talking about” and 10 be scaled as “Solid understanding”. From total 16 responses, 25 percentage of students had an average level of understanding before the courses. Figure 6.9 below shows the level of understanding of system development after the courses.

37.5 percentage of students had chosen nine as their system development understanding level after the course, and 6.3 percentage chosen five as the minimum level of their understanding while the minimum level was two before the course. This shows that the slow learners as same as the quick learners, gained better understanding in system development after the courses.

I have asked them also to rate their own modeling understanding before and after the course. The figure 6.10 shows the level of understanding of 16 students before the courses.
The 18.8 percentage of students rated their own level of modeling understanding as eight before the course. While 37.5 percentages of students rated their own level of modeling understanding as 9 after the courses. It shows the student’s improvement in modeling understanding after the courses, figure 6.11. In chapter 9 this improvement will be compared with responses from students in 2015 to confirm that if the changes in 2016 were helpful for students in terms of better learning outcomes at the end of the courses.

The minimum level of modeling understanding after the courses was five, and the minimum level before the course was two, which is shown in figure 6.10.

The obtained data from questionnaire might include some bias which needs to be considered in results. In Figure below, you can see two responses of students with and without answering the checkpoint questions. The students who respond to questionnaire without the checkpoints question could reduce the reliability of the result. See figure 6.12.
In figure 6.12 the learner’s modeling understanding has improved from 2 to 5 during the course. The students’ answer to the checkpoint question might confirm the improvement in this case, while some of the students did not answer the checkpoint questions.
In figure 6.13, the learner’s modeling understanding has improved from 4 to 9 during a course. But the checkpoint question has not been answered in this questionnaire, which causes bias in data. How can I be sure that the learner really achieved a solid understanding of modeling during the course, while he or she did not answer the checkpoint question? Unfortunately, due to the time and resource limitations of this thesis this question cannot be answered.

6.2.3 Data Transformation

The students were asked to rate the level of usefulness of models during the development, from 1- 5, where one stands for “Not useful” and five stands for “Very useful”. The Figure 6.14 below shows the most popular models from students’ perspective:

To which degree did you find the specification models/techniques useful for the implementation part with IFML/WebRatio? (From 1 least to 5 most)
In 2016, students rated the UML class diagram and the use cases as the most useful diagrams, consequently, the business model canvas, personas, stakeholder maps and service journey were not perceived efficient and useful during the process. It is thus suggested that these modeling techniques get a lower focus in the courses in the future.

As I discussed in 5.2.4, data transmission could analyze against understanding and problem solving competence. The result of both interviews and questionnaire will be compared and analyzed with respect to Jens Johan Kaasboll arguments in chapter 9.

### 6.2.4 Individual and Group Assignments

From total 16 responses to the questionnaire, 12 students answered the question regarding the individual and group assignment effectiveness in
learning and understanding. The answers are shown in the following table.

<table>
<thead>
<tr>
<th>Students</th>
<th>Which one was more effective for your learning and understanding, individual or group assignment? Why?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Individual</td>
</tr>
<tr>
<td>2</td>
<td>Individual</td>
</tr>
<tr>
<td>3</td>
<td>Group Assignment</td>
</tr>
<tr>
<td>4</td>
<td>I prefer individual assignments on smaply, Strategyzer and balsmiq. The final Webratio project can be done as group assignment.</td>
</tr>
<tr>
<td>5</td>
<td>Individual allowed me to learn more about the inter-workings of the specific tools where the group assignment taught me how to utilize those tools with a team</td>
</tr>
<tr>
<td>6</td>
<td>I think a combination is useful.</td>
</tr>
<tr>
<td>7</td>
<td>Group we each have a part that has to work with the other parts so we learn about them that way</td>
</tr>
<tr>
<td>8</td>
<td>I did not learn much from the individual part of the second assignment, so it has to be the group assignment.</td>
</tr>
<tr>
<td>9</td>
<td>I think both have been effective, but of course the individual forces you to do everything yourself and you learn more from that. But it is nice to have groups to work with so that we can discuss and learn from each other.</td>
</tr>
<tr>
<td>10</td>
<td>Individual</td>
</tr>
<tr>
<td>11</td>
<td>Individual. Learn more from individual</td>
</tr>
<tr>
<td>12</td>
<td>Individual and group assignment both are important to get some understanding and both have their own importance</td>
</tr>
</tbody>
</table>

Table 6.1: Effectiveness of individual and group assignment by learners 2016

Among the answers, 33.3 percentage of learners perceived the individual assignments very useful. Between individual, group, and the combination of both type of assignments, 25 percentage learned more effectively from group assignments and 41.6 percentages recognized the combination of both individual and group assignments as the most effective method. These results will be discussed in summary and more in chapter 9.

6.3 Summary

Below the questionnaire results are presented in terms of analysis related to the learning model.
<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill</td>
<td>Using guidance BA/SA/MDE/RE tools, and discussion with teaching assistance</td>
<td>Working with relevant examples, demonstrations, video tutorials and individual assignments</td>
</tr>
<tr>
<td>Understanding</td>
<td>Functional and structural understanding attending the lectures, provided learning materials and exercises were effective</td>
<td>Functional and structural understanding attending the lectures, reviewing provided learning materials, examples, individual/group assignments and structural models were sufficient, the challenge was to learn about different tools</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Inline help, reviewing provided learning materials, feedback on practical exercises in lab hours by teaching assistance</td>
<td>Discussion in group, using learning materials, feedback on individual/group assignments and the main project by assistance.</td>
</tr>
</tbody>
</table>

Table 6.2: Questionnaire results

The results on skill show that individual assignment works well, and combination of both individual and group assignments help learner for better understanding. The outcomes on problem solving competence show that better level of understanding can cause better data transmission and as a result improve the problem solving competence. The main findings which have been validated by triangulation technique during this study, will be presented in next chapter to provide a better overview for readers.
Chapter 7

Observation and Document analysis

I conducted three passive observations with all groups at the University of Oslo. Due to time and budget limitation scheduling a trip to Florida was impossible for improving the data quality and prevent of bias in data.

7.1 Observation - 2015 - UiO INF5120

The first observation was after the initial lectures in Webratio while students were trying to get skill and understanding of the concept and the second and third one was conducted while they were working on the main project. In all sessions students were working in a group and I took notes of all students’ group discussions and interaction with each other.

I have chosen to highlight one of the more interesting observations from the groups. In one of the groups, there was a student who was not interested in IFML at all. He came to me before starting the session and told me that he has got many problems with Web radio but the thoughts that IFML is easy and the main problem is working with Web radio with too many limitations. He preferred more to write code. The group asked me about their problem related to work with the backend and the database, and I showed them the correct video tutorial to work with. Three of them tried to implement the project individually in their computers besides all their group works as well.
7.1.1 Observation Summary

Here the observation results are presented in terms of an analysis related to the three levels of competence building, namely, the development of students’ skills, understanding, and problem solving capabilities.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill</td>
<td>IFML video tutorials and provided learning materials by Webratio group were effective</td>
<td>Learning from relevant IFML examples and implementing apps with IFML exercises</td>
</tr>
<tr>
<td>Understanding</td>
<td>Functional and structural understanding of a domain specific language by working with practical IFML examples provided by Webratio group and discussion either with group members or assistance</td>
<td>Functional and structural understanding by using IFML published book. Lack of time was a challenge for group works</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Not all group members worked at the same level or got the same level of skill while working with IFML</td>
<td>Some parts of the main project like connecting to the server was challenging and time consuming for groups which could have effected on the other parts as well</td>
</tr>
</tbody>
</table>

Table 7.1: Observation Results

To achieve better skill most of the students watched the video tutorials and the difference between those who did not work with videos and who did obviously in their discussions. Further to get better functional and structural understanding they had many group sessions with their group members and as the last option for more complicated problems discussion with the teacher and me as a teacher assistant were their preferred learning methods. I have observed different work process from group to group while they were working on the main project. Depends on their background, their understanding of the concept and their interest in the subject, group members’ contribution were dissimilar.

Hence for skill level, the video tutorials with example templates were helpful for learners and regarding the next level, understanding, and the observations conclusion was IFML is a complex language to learn in the context of developing mobile and/or web applications. The observations on problem-solving competence show that different groups were working differently with respect to how they divided work and responsibilities.
A recommendation after these observations is to introduce modeling for execution with IFML earlier on in the course. Also, rotate roles in the groups to allow everyone to develop relevant modeling competence is also important.

In the next section the document analysis result will be presented.

### 7.2 Document Analysis - 2015 and 2016 - FAU CEN6075 - UiO INF5120

Document analysis was done for the learning materials, student exercises, and incremental project deliveries as well as for the exam papers in both 2015 and 2016 (for the MBSD course, the RE course was graded only by project deliveries).

#### 7.2.1 The Main Project

Here I present two of the delivered projects by students in 2015.

“SenseIT” application, has been developed by students at the University of Oslo and Florida Atlantic University, in autumn 2015. Students have been asked to describe the models within system business architecture and service offering, for “SenseIT” a new imaginary startup company. In a later phase students implemented a mobile application and a web based application by benefiting of Interaction Flow Modeling Language (IFML) and PHP in groups.

Students have designed different applications to offer various services to people who are exposed to the sun. In Figure 7.1, Figure 7.2 and Figure 7.3 below you can see two pictures of two different final group deliveries at the end of the semester.
Figure 7.1 shows the SenseIT website which has been implemented as a service page. This project was submitted by a group of students in the CEN6075 course. The web page contains Ultraviolet indexes which have been retrieved from the sensor. The user can also get the graphical view of the values by clicking on the “Graphical View” button.

The Figure 7.2 and 7.3 show the implementation of the cross-platform mobile application which has been submitted by a group of students in the INF5120 course.
Figure 7.2 shows the login page and Figure 7.3 the profile page as the main screen of the application. In next flow the user can register the skin type by clicking on “Skin Test” button and can choose a particular sensor from the existing sensors list to get the UV values in the user profile page.

The assignments aimed to give an overview of model-based system development advantages and disadvantages to learners. Getting skill and understanding in modeling within different perspectives in the context of design, analysis, and realization of the system. On other hands learning how to reuse the models in other software development projects was in focus in the given assignments.

These two groups were selected as a sample among the students because from each group I have interviewed two members. By analyzing their progress in the development of the project and their interview transcripts, I try to study their individual understanding of the subject and learning outcome at the end of the courses.

I named the groups as Group 1 from CEN6075 which has three members, and Group 2 from INF5120 which has four members for further analysis in chapter 8.
7.2.2 The Exam Sheets

Analyzing the exam sheet of students can demonstrate the overall level of understanding at the end of the course. The written exam consisted of three questions. Question 1 was composed of five sections, while question 2 and 3 have three sections. Each section of questions has been scored which provided me a scale for further analysis. Figure 7.4 shows students score from each section.

Question 1 was related to business architecture and requirements models which consist of five sections. The average score for question 1 confirmed great understanding of this subject during the courses. The average score for question 2 which was related to the domain model and IFML has decreased and at last but not least the question 3 which is related to the meta-modeling and graphical editor has the lower average.

<table>
<thead>
<tr>
<th>1a</th>
<th>1b</th>
<th>1c</th>
<th>1d</th>
<th>1e</th>
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Figure 7.4: Students score from the writing exam 2015

The analysis of the results from the written MBSD exam (4 hours practical case) showed that the students generally scored well on the business architecture and system architecture/IFML part. The questions on the model-driven engineering and meta-modeling got a lower score indicating less problem-solving competence in that area (creating a meta-model for a described language). A document analysis of the delivered exercises showed that some students were not clear on the difference between domain modeling and meta-modeling. For 2015 the MDE part on creating a DSL editor was only done as a group exercise at the end of the course, and a recommendation is to later do meta-modeling and DSL
exercise as an individual exercise – or as "pair modeling" earlier on in the course. The exam evaluation from 2016 showed the same pattern. The scoring in the MDE part had improved slightly but was still lower than the other parts. A question on SoaML modeling, which had not been practiced in the project nor in any particular exercises, got a low score – showing the importance of providing practical exercises/projects for all important learning topics.

7.2.3 Document Analysis Summary

The document analysis results, in terms of the three levels of competence building, namely, the development of students’ skills, understanding, and problem solving capabilities is presented in Table 7.2.

<table>
<thead>
<tr>
<th></th>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skill</strong></td>
<td>Provided assignments and learning materials were helpful but the lack of demonstration of individual abilities by no individual assignments. Exam showed good individual skills for BA/SA and less for MDE</td>
<td>The quality of the tool usage seems to have been adequate, but the usage of a large number of tools implied less sophisticated usage of some tools. The exam was in written form without use of tools, and the basic techniques seem to be mastered by the students</td>
</tr>
<tr>
<td><strong>Understanding</strong></td>
<td>The understanding has been documented through the provided documents and associated presentations. The exam result analysis showed that the MDE part was less understood.</td>
<td>There were quality variations between the different groups in terms of the elaboration of their understanding and level of quality. The MDE assignment was less elaborated compared to the main project.</td>
</tr>
<tr>
<td><strong>Problem Solving</strong></td>
<td>Group assignments - The main project deliveries confirmed good problem-solving competence in the group but by exam sheets, the MDE part of the courses needs to improvement related to providing the problem-solving capability.</td>
<td>Group assignments - The main project deliveries confirmed good problem solving ability, but there were quality variations between the groups. The simplicity of the MDE assignment implied less quality on this.</td>
</tr>
</tbody>
</table>
The table 7.2 shows, the video tutorials among all learning materials were useful to gain better skill and understanding for students. The appropriate content, and enhancing the verbal explanation simultaneously by visualization created adequate video tutorials as a learning material [24]. Further, regarding problem-solving competence, the main project was the most effective learning material.

Learners’ skill, understanding, problem-solving competence, data transformation and use of individual/group assignments will be analysis in chapter 9 by considering all findings.
Chapter 8

Analysis and Discussion

More specifically to concern learning Model-Based System Development, I have defined three research questions which have been presented earlier in the introduction chapter.

1. Skill – What is important in order for the students to get good syntactic and semantic skills for MBSD? To which extent does learning background of students in modeling or/and programming effect the transmission of requirements specification into realization phase?

2. Understanding – What is important in order for the students to get good syntactic and semantic understanding of MBSD? Are there any dependencies between having a modeling background and a programming background among students for developing a structural and functional understanding of modeling languages?

3. Problem Solving – What is important in order for the students to get good syntactic and semantic problem-solving capabilities of MBSD? Is it an advantage to using more individual exercises versus group exercises to advance the learning of modeling techniques for each student?

In this chapter, I discuss and analyze my case against the earlier arguments which have been mentioned in “Learning Process” chapter, to answering the research questions. Students’ background, skill, understanding, problem-solving, learning in group vs learning individually and data transmission during learning process will be analyzed. By referring to the interviews, questionnaire, observations and documents analysis results, the learning outcome of the students from 2015 will be compared with the learning outcome of the students from 2016 and the results will then be discussed related to the earlier presented argumentation.
8.1 Data Analysis and Findings

8.1.1 Learners Background

Programming and modeling language like other languages consist of rules and symbols. While discussing the syntax and semantics of languages to learners, the instructor should take into account students’ academic background, the understanding level of concepts and working experience if they have used languages in practice [24].

According to Chandler, it is important to keep the cognitive load low during a learning process [37]. For instance doing a project by using modeling language which learners do not have an appropriate structural understanding of that require a high cognitive load. Improving the level of understanding can effect on both the learning process and the quality of projects.

According to the interview transcripts from group 1, one of the students in past years has worked as Linux system administrator. Out of the school, he is not working with software architecture and he rated his own level of understanding in software engineering as seven, from 1 to 10. He usually working with implementation of the projects and he thinks that having to design and document everything just slowed the whole process down.

From group 2, one of the students is Ph.D. candidate in model-based system development, with four years education in software engineering from Spain. He has rated his own level of understanding in software engineering as eight, from 1 to 10. He thinks that real world is different from universities education, so he is not sure if his learning outcomes from the university can be supportive for his future work.

The second student has worked as a system developer in an IT consultant company since seven years ago. He has rated his own level of understanding in software engineering as eight, from 1 to 10. At his work, the process is more casual than this course. They utilize the scrum methodology and usually, they have been given a pdf file of some diagrams or data flow to work with. He is using modeling out of the school but not in the same level as the methodology which has been used during the course. And both students are graduated from Florida Atlantic University in computer science.

The other student has three years education background in computer science-programing and is accomplishing her master’s degree in programing, and network. She has rated her software engineering knowledge as five, from 1 to 10. One of her earlier courses that dealt with the creating models and modeling the software before coding was her motivation to learn to model. She thinks that her previous courses were basically a lot
syntax learning.

For these two submitted projects, the sample group of learners all have modeling background in different levels. The lowest level is related to work with some project in bachelor degree and the highest level related to a Ph.D. study in model-based system development. Concerning programming background, the highest level is seven years’ experience as a software developer.

Both groups have been asked to implement the project in specified time. Group 1 and group 2 have delivered applications which consisted of some fully implemented features like log-in and displaying the data which has been retrieving from the server side. The group work with the project can be a challenge to analyze the individuals. A summary of all transcriptions shows most of the learners have a programming background and have worked as software engineer for some years.

From total 16 responses to questionnaire in 2016, 75 percent of students had programming and network background in courses. But not all of them have worked with modeling before the course, which can be significant in the analysis of their understanding and problem-solving competence during the courses. 6.2 percent of students had modeling background. These data further can be considered in the further analysis of learning process during the courses.

According to Jens Kassboll (2015) [24] repetition and imitation are among learning methods which might ease the learning process, therefore the background could affect the cognitive demand of students while learning a particular concept. The related background to the subject could be supportive of easing the imitation process and could enhance the repetition as well which could gain better skill as result.

But how may programming background and modeling learning be related? Considering syntax and semantic aspects, programming and modeling languages as being two different type of languages are similar to each other. Realizing how and why these languages are similar, might be helpful for learning and data transmission [4], and to figure out this similarity syntax/semantic structural understanding and problem solving competence might be required [24]. Further, I am analyzing understanding and problem solving competence of learners.

According to the constructivist perspective, previous knowledge of learners and learning outcomes are related [24]. Thus the learner’s level of knowledge might be an essential factor in choosing the learning material and learning methods.
8.1.2 Learners Skill and Understanding

According to Kaasboll (2015) [24], understanding is one of the learning steps. Learning happens in three steps; an action, thinking about the action which could cause understanding of concepts and discover the relationship between the concepts which is called abstract conceptualization. Jens Kaasboll (2015) [24] discussed in addition to functional, structural, syntax and semantic understanding, where functional understanding is the lowest level and semantic understanding can perceive as the highest level of understanding in learning. In chapter 4, you can find more description.

In group 1, between various learning materials and methods students recognized discussing with group and video tutorials more efficient than the lectures and teaching assistants sessions. In group 2, they mentioned that they were lucky to have serious and active group members to work with, and they recognized group discussion and video tutorials were more beneficial than lectures or provided lecture notes. Both groups identified the group discussion and video tutorials as the most effective learning material which confirms the observation and document analysis results.

For both groups, there is no significant difference between the average level of functional and structural understanding. According to interview transcriptions, in group 1, for the first student, the rating of functional and structural understanding of the project were eight and eight. Respectively for the second learner, the ratings were eight and seven. While for group 2 the functional and structural level of understanding for the first student was both ten and for the second students was seven and four. Observation and document analysis results show working with assignments and the main project was helpful for student’s skill and understanding while the lack of time and detailed user manual were challenged during courses. Total transcriptions from students in 2015 show average of functional and structural understanding as 7.49.

According to questionnaire results, the total average of modeling understanding level before the course was 5.71 and the minimum level of understanding was 2 in 2016. The total average of system development understanding level before the course was 6 while this total average after the courses was 8.14. According to the interviews transcriptions from students in 2015, the total average of functional and structural understanding was 7.49, while the total average of functional and structural understanding in system development of students in 2016 after the courses was 8.14.

<table>
<thead>
<tr>
<th>MBSD Understanding</th>
<th>Total Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewee - 2015</td>
<td>7.49</td>
</tr>
<tr>
<td>Questionnaire - 2016</td>
<td>8.14</td>
</tr>
</tbody>
</table>

Table 8.1: MBSD understanding in 2015 and 2016 at the end of the courses
The level of understanding for students are not independent of other factors like motivation or being slow or fast learner [16].

Further comparison between students in 2015 and 2016 from assignments and written exams at University of Oslo shows that learners have got a better understanding of business architecture and requirements models than the other subjects of the course. Also between IFML and meta-modeling, IFML gained the highest exam scores which indicate better understanding as well. By reviewing the individual responses I can see that one of the factors which could have affected on their perception or understanding of the models is their background.

Students when be given some sample of exams questions, they mostly focus on learning that specific part of subject matter rather than the whole. In addition the type of the exam questions is significant as well, which address more the skills or understanding of the learners. If the assessment is based on skills evaluation, there is a small chance to measure the understanding level of the students in the exam compared to the exams that focus more on the understanding of the learners [26]. In an analysis of interview transcriptions and documents I tried to consider the above as well.

All findings from courses in 2015 and 2016 may confirm that as consequence of improvement suggestions, the skill and understanding of students in 2016 have improved.

Table 8.2 and 8.3 show the analysis results for learner’s skill and understanding.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Interviews</td>
<td>Attending the Lectures, learning to work with BA/SA/MDE/RE tools with user guide and teaching assistance guidance</td>
<td>Attending workshops related to tools demonstrations, video tutorials and exercises and working by relevant simple examples</td>
</tr>
<tr>
<td>From Questionnaire</td>
<td>Using guidance BA/SA/MDE/RE tools, and discussion with teaching assistance</td>
<td>Working with relevant examples, demonstrations, video tutorials and individual assignments</td>
</tr>
<tr>
<td>From Observations</td>
<td>IFML video tutorials and provided learning materials by Webratio group were effective</td>
<td>Learning from relevant IFML examples and implementing apps with IFML exercises</td>
</tr>
</tbody>
</table>
From Document analysis

Provided assignments and learning materials were helpful but the lack of demonstration of individual capabilities by no individual assignments. The exam showed good individual skills for BA/SA and less for MDE.

The quality of the tool usage seems to have been adequate, but the usage of a large number of tools implied less sophisticated usage of some tools. The exam was in written form without use of tools, and the basic techniques seems to be mastered by the students

| Table 8.2: Learners Skill Analysis Results |

<table>
<thead>
<tr>
<th>Understanding</th>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Interview</td>
<td>Functional and structural understanding by attending the lectures, reviewing provided learning materials and exercises</td>
<td>Functional and structural understanding by attending the lectures, reviewing provided learning materials, examples, working with provided exercises and structural models</td>
</tr>
<tr>
<td>From Questionnaire</td>
<td>Functional and structural understanding attending the lectures, provided learning materials and exercises were effective</td>
<td>Functional and structural understanding attending the lectures, reviewing provided learning materials, examples, individual/group assignments and structural models were sufficient, the challenge was to learn about different tools</td>
</tr>
</tbody>
</table>

The analysis for syntactic skills shows that attending the lectures, work with BA/SA/MDE/RE tools with user documents, provided assignments, sessions with teaching assistance and IFML video tutorials were effective to better skill in the MBSD. However in 2015, the lack of demonstration of individual capabilities by no use of individual assignments could be an improvement area.

The analysis for semantic skills shows that attending workshops related to tools demonstrations, video tutorials, and exercises and working by relevant simple examples were adequate. However, the usage of a large number of tools implied less sophisticated usage of some tools.
From Observations

Functional and structural understanding of a domain specific language by working with practical IFML examples provided by Webratio group and discussion either with group members or assistance.

Functional and structural understanding by using IFML published book. Lack of time was a challenge for group works.

From Document analysis

The understanding has been documented through the provided documents and associated presentations. The exam result analysis showed that the MDE part was less understood.

There were quality variations between the different groups in terms of the elaboration of their understanding and level of quality. The MDE assignment was less elaborated compared to the main project.

Table 8.3: Learners Understanding Analysis Results

The analysis for syntax understanding shows that functional and structural understanding would be achieved by attending the lectures, reviewing provided learning materials, doing practical IFML exercises and discussion either with group members or assistance. Though the exam result analysis showed that the MDE part was less understood.

The analysis for semantic understanding shows that functional and structural understanding would be achieved by attending the lectures, reviewing provided learning materials and working with provided individual (2016) / group (2015 and 2016) assignments. The challenge was to learn about different tools in short time, and the MDE assignment was less elaborated compared to the main project.

8.1.3 Learners Problem Solving Competence

Problem-solving competence can differ for students, working either individually or in the group. To obtain a more precise illustration of individual problem-solving competence, the submitted assignments which all have been done in group and interview transcriptions which included problem-solving routines from an individual had been analyzed.

According to Ormrod (2012) [36], students and programmers need to learn problem solving competence. Exploration, experimentation and troubleshooting competence could lead learners to gain better problem-solving competence. As I discussed earlier in this study while skills
are needed to use IT, understanding is fundamental for problem-solving competence. While functional understanding is needed to explain how input changes to result, structural understanding of a concept is needed to use the learned concept as the basis for learning new ones [24].

From group 1, the first student tried to search the problem as his first attempt while the second one used some tools like an operating system for troubleshooting is his first choice to find a solution. He mentioned that sometimes he spends hours to figure out the problem and then moving forward. The first student, in cases when searching does not help, trying out the troubleshooting.

During the interviews, I asked the students how they usually try to solve their problems eventually while they are working with assignments. Group discussion has been given as an option but for example, the first group tried to puzzle out the problems by searching and troubleshooting individually. According to Grigoreanu et al. (2012) [5], research cycle competence is the ability to define hypothesis to solve actual problems which required appropriate structural understanding. One has to have an understanding of the principle of research cycle of trying one change at a time in order to avoid confusion when comparing achieved result with an expected result. If not following up the above principle, some students might try many changes at a time that could lead learners to more complexity. They might not find out which change is the most effective one [24].

In group 2, the Ph.D. candidate tries to predict next step of the process by the system to figure out the solution but referring to the IFML he thinks, that was challenging for him to follow up the process and at the end, he has got assistance from a sample project. Unsuccessful experimentation could be caused by insufficient functional or structural understanding in IFML [4].

The second student tried different video tutorials. She thinks it is significant to watch and try some practical samples and then reviewing the theoretical aspects of the concept. On the other word, she is building up the fundamental understanding competence to gain better problem solving competence. Video presentation, similar to other learning methods can be combined with functional and structural models which enhance learning process [24].

According to transcriptions 75 percent of students, try to explore different solutions to the problem using the Internet for their first attempt, and 37.5 percentage referring back to the course materials. Among other problem-solving competence, 50 percentage of students discussing the problem within their groups, in the case of being unsuccessful to find the solution from the forums or related communities on the Internet.

*Understanding the concept causes, better problem-solving competence for new*
learners while learning new IT concepts. To gain better understanding of the concept, the learner has to get the syntax and semantic understanding of the related project. Syntax problem-solving competence for example, in this case, needs the ability to correct data in consideration of the rules of the modeling or programming language. While semantics relates to perceiving symbols, signs and related representation systems. It, therefore, considers how the various signs are linked together towards explaining the phenomenon [24].

Table 8.4 shows the analysis results for learners problem solving competence.

<table>
<thead>
<tr>
<th>Problem Solving</th>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Interviews</td>
<td>Related Inline help regarding models, reviewing provided learning materials like presentations notes, teacher and assistance’ feedback on practical exercises in lab hours</td>
<td>Discussion with group, IFML inline help provided by Webratio, feedback on the main project, and repeating the same steps until the problem gets solved.</td>
</tr>
<tr>
<td>From Questionnaire</td>
<td>Inline help, reviewing provided learning materials, feedback on practical exercises in lab hours by teaching assistance</td>
<td>Discussion in group, using learning materials, feedback on individual/group assignments and the main project by assistance.</td>
</tr>
<tr>
<td>From Observations</td>
<td>Not all group members worked at the same level or got the same level of skill while working with IFML</td>
<td>Some parts of the main project like connecting to the server was challenging and time consuming for groups which could have effected on the other parts as well</td>
</tr>
<tr>
<td>From Document analysis</td>
<td>Group assignments - The main project deliveries confirmed good problem solving competence in the group but by exam sheets the MDE part of the courses needs to improvement related to providing the problem-solving capability.</td>
<td>Group assignments - The main project deliveries confirmed good problem solving ability, but there were quality variations between the groups. The simplicity of the MDE assignment implied less quality on this.</td>
</tr>
</tbody>
</table>

Table 8.4: Learners Problem Solving Analysis Results

The analysis for syntax problem-solving shows that related inline help
regarding models, reviewing provided learning materials, feedback on practical exercises in lab hours were effective. However, in group works not all members worked on the same level or got the same level of skill and understanding while working with the project.

The analysis for semantic problem solving shows that discussion with the group, IFML inline help provided by Webratio, feedback on main the project, and repetition were helpful. The simplicity of the MDE assignment implied less quality on this.

8.1.4 Individual learning vs Group learning

As stated by Ormrod (1995) [36] and Bannon (1986) [1] collaboration and pair learning has been important methods of learning. Moreover, Wenger (1998) [45] considers a community of practice (CoP) characterized by three crucial segments related to domain, community, and practice.

The learning process may be accomplished in a sequence of steps where the first and the second actions are respectively performing an action and thinking analytically about what one did [24]. As I mentioned earlier, several studies conducted on how one learns mathematics which supports the abstract conceptualization [42]. Thus learning mathematics and learning IT is similar in this way. From syntax and semantic perspective, correspondingly modeling is a type of language which is presented by modelings objectives and elements.

In questionnaire which has been handed out in 2016, 50 percent of learners perceived the individual assignments as very useful. Between individual, group and combination of both type of assignments, 25 percentage learned more effectively from individual’s assignments. 33.3 percentage prefer group assignments and 41.6 percentages recognized the combination of both individual and group assignments as the most effective method.

By referring to these result and ”Learning Process” chapter it might not be far from reality to state that in modeling learning both individual and group assignment needs to be considered within training.

8.1.5 Data Transmission within Model Based System Development

System development process mostly deals with data transmission from the initial phases into the closing ones [30]. Clarification, interpretation and transmission of data between different stakeholders and distinct phases at all times have been challenging in diverse methodologies. Getting appropriate declaration of the requirement specification in initial
phases could ease the data transmission during the process, despite misinterpretation of specifications and needs could cause challenges during the process and deficiency in results.

In both groups, students have used different descriptions for the relationship between the requirements specification models and the realization phase. They discovered various models as helpful, useful, important, pretty important, interesting and not useful.

In group 1, one student who has worked as Linux administrator during the past few years described the UI mockups as definitely useful, and use cases important. He mentioned that BPMN was not useful regarding the implementation phase of the project.

The second student with seven years’ experience as software developer find out the user stories and use cases as the most important diagram in the first phase. Moreover, he referred to his personal experience:

“I mean personally myself when I’m working on a project or whatever use cases are the first thing that comes to mind is an essential ingredient in implementation.”

In group 2, the Ph.D. candidate in model-based system development has described the user stories and use cases as really useful diagrams. He mentioned that for creating the UML class models their logic and their thoughts was exactly as same as coding thinking.

“We put a lot of code-related things, we were thinking if I’m going to code this app, what I’m going to need? What classes do I need?”

The second student with three years education background in computer science discovers the user stories, use cases, and the journey map the same and they are helpful to declare the customer’s needs. Concerning the UML class diagram she was unsure that if it was helpful for implementation phase or not.

Certainly learners’ syntax and semantic understanding level and syntax and semantics problem-solving competence could be among the important factors in data transmission [24]. Furthermore, the semantic consistency from phase to phase could support the learners or user for better data transmission and as a resulting improvement in productivity. As I discussed earlier the learner’s background and extending understanding level could be related as well.

In 2016, students rated the UML class diagram and the use cases as the most useful diagrams, consequently, the business model canvas, personas, stakeholder maps and service journey were not perceived efficient and useful during the process.

Later in this chapter, I discuss findings reliability, and in next chapter as consequence of findings, I will provide a suggestion to improve learning
outcomes of courses.

8.2 Findings Reliability

Triangulation as a method in this thesis could increase the credibility, validity, and reliability of the findings. However due to the limitation of time, budget and resources the biases should be considered as well.

Social cultural perspective with respect to learning not being explored in this thesis, due to time limitation which could cause some data bias during analysis. However, in research questions expanding and analyzing the data I have tried to consider the defect.

It is important that researcher is close to the people and the case study and interact directly with them in their own settings, which was impossible for me when it comes to Florida Atlantic University students. However, in the coding process, I tried to distinguish between the insider’s and the outsider’s point of view when analyzing [28].

For both groups, I tried to interact, talk and follow up the interviewees actively without any digressions of the topic. Of course, the direct interview experience differed from online interviews. This difference could be more obvious between Oslo students and Florida students since there has been a relation between me as an interviewer and the students in Oslo during the semester. Still, after each interview, I have tried to go through and listen to the interviews over and over to improve the next one.

From the interview experience, I figure out that students’ different perspectives can affect to their responses when I asked them to rate their own level of understanding. Some answers to this questions were different from my own impression of individual students based on observation sessions and their assignments and exam sheet. So in the questionnaire, I have designed some checkpoint questions in addition to rating questions to prevent bias in data.
Chapter 9

Conclusion

9.1 Outlines of study

The role of human factors during system development process and how these factors would affect the quality of the final product, the information systems is not hidden. One of the phenomena that I believe would directly cause better productivity in system development is the learning quality of contents. Among the results of better learning outcomes, better communication between different stakeholders, better data transmission during the process and decreasing in implementation time and budget are undeniable.

The research questions set focus toward describing characteristics of learning concept, I will also try to be prescriptive in terms of further research and improvements in models education. The main points are that the course from 2015 wish to demonstrate that requirements models can lead to executing programs/codes – either with IFML or PHP – and that we will examine if this actually works, and to which degree did it differ for those who had programming or Modeling background in connection to realization with IFML or PHP.

Furthermore, it was studied that to understand how to do modeling one has to be taught individually and not as a group. In one interview, in particularly exam analysis, we witnessed that there were few of learner who worked in the group did not understand the depth of for instance the data transmission between phased during system development or neither get appropriate understanding in BPMN. Some will perhaps argue that they got low score simply because it was the last assignment and that they did not have sufficient time to answer, and it would be essential to consider the biases.

Furthermore, we just have students ID number for the exams, so we do not really know which students have responded poorly, and which
role/responsibility they had assumed in the groups. But on the other hands, the interviews input was more helpful in this manner. For instance, among interviewees, there were some who mentioned that they had not worked much with “IFML” in groups. Because there was one in the group who knew IFML better than the others.

The conclusion of the analysis that was taken into account in the courses of 2016 is that for both groups, but in particularly those with a programming background, it is important to present/use executing models as early as possible in the course. We have, therefore, moved the use of Webratio/IFML to earlier assignments in courses, and we do a follow up with IFML in the latest assignment.

The consequence or another conclusion of analysis was that we have made individual assignments, in addition, the group assignments too. The first assignment one has to make an app with Webratio/IFML, where all students have to do individually instead of group work. It appears that individual assignment appears to be better since students only then would get a better in depth sense of understanding for modeling. This understanding cannot be acquired through group discussion.

Once has understood this then one could participate in group work, but until one understands it, it is easy to participate in group discussions without understanding the depth of modeling. We have in exam analysis, among others, noticed that there are some who do not understand the principles of Meta-modelling at all. This probably is because they have done this as group work without having any individual responsibility for modeling in the group.

In INF 5120 course, we have primarily concentrated on group assignment in these past years, and only through exam analysis witnessed that some have not understood of some main subjects. For instance, we experienced through an analysis of exam results from 2015 that there were many who had responded completely wrong. Since we have had no “individual” assignment about that particular subject, therefore, in the year (2016) made we some assignments be answered individually. So one aspect of the discussion was individual learning versus group learning.

9.1.1 Recommendations

The following recommendations could be extracted from the study:

1. Motivate the students, by ensuring that the course ends up with a working application/service/app demonstrating a Minimum Viable Product (MVP). These working applications show the usage of connected models from start to finish with appropriate tools for model-driven engineering. The motivation can help students to get netter skill and
further better understanding in learning cycle.

In addition, student’s background on programming/modeling at the beginning of the course could be evaluated. With a historical majority having mainly a programming background ensure an early start in the course with tools that creates actual working code and implementations from models. Ensure to demonstrate the transformation and mappings between various models throughout the development process.

2. Introduce executable models (such as IFML) at an early stage in the course for those who does not have modeling background. Modeling earlier in course could cause lower cognitive load for learners later in learning, understanding and using the modeling in system development. The same result could be found in connection to WebRatio or IFML with potential differences between those who have actually used IFML, and those who just have been an observant in the group. Those who has practiced the models during the group assignment might be better in understanding and exams as well. This may not be easy to detect by analyzing the results of the exams.

3. The first assignments in modeling should be made as assignments that are solved individually and not as “group work” assignments, in order to gain a more in-depth understanding for practicing modeling, which could be significant in later phases during system development process. Particularly to motivate those with programming background, to give a general understanding that modeling can be connected through the whole system development.

Introduce modeling exercises with quality review and feedback during the different steps of project development, focus initially on individual learning and related discussions through pair modeling and group/class discussions. Provide individual assignments in initial phases to achieve better understanding and ask students to discuss with each other after they have initial knowledge.

9.2 Future Course

The planning for future courses is now taking advantage of the analysis and recommendations from this thesis.

Based on the recommendations from this thesis the following changes has been done for the INF5120 course that is being provided in the spring of 2017.
1. Motivate the students, by ensuring that the course ends up with a working application/service/app demonstrating a Minimum Viable Product (MVP). A project focus has been on the creation of a working application for “Smart Buildings” with Apps/Web portals and IoT/Sensors, and the use of executable modeling languages with IFML and ThingML.

2. Introduce executable models (such as IFML) at an early stage in the course. The focus on App/Web Portal development with the IFML domain specific language and supporting UML/Metamodels has been increased, and introduced during the first weeks of the course.

3. The first assignments in modeling should be made as assignments that are solved individually and not as “group work” assignments. The first Oblig 1 assignment in the course includes a requirement for each student to make their own database driven web portal implemented through the use of IFML and WebRatio.

4. The usage of a large number of tools implied less sophisticated usage of some tools, and a challenge was to learn about different tools in a short time. The number of tools used in the course has been reduced by having a less focus on Business Modeling, and a removal of the whole Service Design part including the removal of the use of the Smaply and ExperienceFellow tools. The use of the Balsamiq MockUp UI design tool has also been removed.

5. The document analysis of the exam result analysis showed that the MDE part was less understood. The simplicity of the MDE assignment implied less quality on this and the MDE assignment was less elaborated compared to the main project. More emphasis on core UML/IFML modeling and the MDE part of meta-modeling has been introduced, also focusing on the metamodels of the business models. The core MDE part has still focus on the Modeling of Structure and Behaviour in "systems" including the creation of Model Driven Engineering tools – and the creation of tool support for new domain specific languages, but will be emphasised more in the course.

The approach of doing an initial analysis of the knowledge level of the student as recommended in this thesis will be applied for new students of the course, and a follow up on the analysis of the results from the course will also be analysed through a questionnaire, combined with interviews, observations and document analysis – based on a light weight approach conducted with the help of teaching assistants. The planning and analysis of the courses based on the learning model proposed by this thesis focusing on the aspects of skills, understanding and problem solving will be continued. It will also be considered how to expand the
discussion by collaborations among multiple related courses offered by different organisations.
Bibliography


Chapter 10

Appendix
Appendix A

Interviews
Informed Consent form for Master Thesis interview

The purpose of this interview is to gather information about learning process of students and see how the learning outcomes has affected the realisation/implementation phase, by analysing the effects of the initial model based system development approach.

The data shall be used only in a master thesis for the Institute of Informatics at the University of Oslo.

I hope that it adds to the body of knowledge to improve the learning of model based system development in institutions.

Supervisor: Arne Jørgen Berre
Researcher: Hanieh Alibakhsh - University Of Oslo
E-mail: hanieha@ifi.uio.no

Thank you for your willingness to participate in the interview. Participation is voluntary and you are free to withdraw at any point. In such cases all the data will be immediately deleted.

The interview will be recorded and the files will be stored until the project is completed. Only the supervisor and researcher will have access to the recording and any data from the interview will be anonymized.

Signature
Date
Participant

Signature
Date
Researcher
Interviewee: Okay, so my name is [unintelligible 00:00:04] I'm from Spain. I'm 27 years old. Will be 28 in one month or less or two. So I started my Master in Spain with a grant and then start researching as part of my master. And started the PhD here in Oslo, like half-year ago or one year ago, I don't remember the date because it's not the same the day I started, the date that is in the document right now that I don't know, so this is basically -- what I did in Spain was Computer Engineering, which is more or less computer science or software engineering because in Spain we call things differently than in other places. So it's a four years degree. I don't know, what else. I love computer games. My final work for the degree was a computer game for Android.

Hanieh: And your PhD study's about?

Interviewee: Yes, and my PhD studies are about model based system development. No system. I'm working with a company that are producing induction cups, so they need an SPL. Model based SPL to help developing the framework that is put into the induction cups, and they were having problems with redundancy because they were copying the induction cup model or the code, pasting it and modifying some lines, they have been doing that through a lot of years, so at the end, when they someday discover a bug in the very first induction cup, they say, “Okay, I fixed the bug. So now, how to spread the chains into the copy-- copy paste that we have already done.” It's not possible. Or questions like, okay, if I change this line, this inductor for instance, which of the induction cups that we already have are going to be modified or-- and they weren't able to answer this kind of questions, so they decide to change the way of doing the code instead of [unintelligible 00:02:25] approach that they were using to a model based SPL.

Or they can have common parts, variable parts, modify them, and reuse all that parts to build the model and produce the code at the end. That's more or less the idea. It's okay. It's nice.

Hanieh: So I heard the course was really related to your background and the study. So you have some backgrounds in just-- I mean, you already answered the next question but how would you rate your own level of software engineering or modeling architecture, from 1 to 10?

Interviewee: Modeling would be an eight for instance. The problem is that I haven't been ever involved into a real company, working as a software engineer for five years is not in my CV so I think that you can learn a lot in the university but real world is different, so at the end, I don't know until I go to a company and say, “Okay, what are you doing?” And see if it's the same I have learned or not. That's the--

Hanieh: But already you're rating as eight.

Interviewee: Yes.
Hanieh: Cool. So could you just compare about, I mean, through this semester, so you have used some methodologies and technologies. I mean we are just doing all our interview, we are focusing more on the IFML and model based system developing in the whole project. So of course you have used some other technologies and methodologies before that, could you just give me one example and compare these two? I mean, one is IFML and model based system developing and the others are one from your experience.

Interviewee: Okay. So, for instance, before -- I'm not sure. I have used some MDD tools that were supposed to produce the code from a model. Similar to IFML. And the problem with those tools, they were really old ones, like 15 years ago -- the tool has 15 years, and the problem were that the tool was really ugly, difficult to use, I mean when you are going to model something, you expect some graphical modeling, not text-based or not rebuild based modeling tool. So the problem with that tool was that at the end, the logo -- not logo, the motif of the tool and the company was no code necessary, no code anymore. You just model and you don't need to code anymore. But at the end, you end up coding in a small box because at the end they need to code some small parts of the app, so what's really frustrating because you end up coding in small boxes with different language as you were used to, but code in some kind of loop or -- at the end, you need to code. And I was like, "You lied to me, you said I wasn't going to code and I end up coding." With no help, like highlighting the syntax or things like that, that you have when you are really coding. And with IFML, the experience was different because the tool is -- the webratio tool is really nice, so you feel like, "Okay, this is not coding and yes, drag and dropping, so I'm not coding yet."

There are some parts where you suspect that you may end up coding, like when you open some of the palettes, and then you have something like a loop or -- it was a loop. It was loop in the name, or those conditional elements and you say, "Okay, I'm going to create a model, but if the model have whiles and conditionals, what's the difference between an algorithm?" So are you coding or not? That's more or less the problem I saw. But we don't need to go to really in with the IFML, so I think that things are getting better, and with my PhD topic, I tend to think that someday, coding will be obsolete. Not nobody will code, but it won't be the common practice for all people coding.

As happens with the assembler code that nowadays nobody needs to go into the assembler code unless he wants to do that for their purposes like, I don't know, if they want to achieve really high performance or they are doing some kind of driver or whatever, they can use the assembler code. But nobody doubts that when you compile, the assembler code produced is going to work, and nobody is thinking about, "Maybe it doesn't work. Maybe the compiler failed." Nobody thinks that. You know that the compiler is doing the right work and do their work even better than you could do it if you try to because they built compilers to optimize and to reduce all the number of operations, so the compiler is much better than me doing that task, but nowadays, MDD approaches are not better than me coding.
I can code much better than an MDD approach or a model based approach that then stored into code, I think, but will change in some years. That's what I think. I hope.

[Hanieh: [laughs]]

**Hanieh:** Okay, I've got some background. I mean, I know something about you, but now I'm just going to ask you about some learning... I mean, how you learn or what kind of person are you -- performance-oriented person, or learning-oriented person. First I can just ask you how you can see yourself, as a performance-oriented person, or learning-oriented person.

**Interviewee:** I don't really get the question.

**Hanieh:** If you just need or you prefer to see that result. I mean -- or you just prefer to learn, or how you manage or how you can see yourself, are you more like learning-oriented or practical, performance-oriented.

**Interviewee:** Practical. I think that practical -- I prefer to do the things and to try out the things and to get the hands on it rather than study something. Theoretically, it's to do this and that, so let's try. I prefer to see the things moving rather than just on an abstract way that--

**Hanieh:** So you're practical, but normally, when you are learning some new IT concept, whatever, I mean some people, usually, they have some -- maybe strategy or technics to learn step-by-step. Will you just explain how you learn one new IT concept?

**Interviewee:** How do I do that? Usually, first you need to have the theory, explain or read or whatever, but I don't get all the concepts until I try out that theory, so they can explain you, “Okay, our service is going to do this, this and this, and then, we'll expose this, and then the client will connect through this method or this other.” I get the overall picture but when I try that out and see the messages flow in is when I say, “I understand this. I really understand what's happening.”

And then, after that point, I can learn more theoretically or in an abstract way, but I need to have some of the base concept in my hands. I'll try it out. Otherwise, it's like, “Okay, theory, theory, theory.” But I don't believe everything, so I need to have something to try out, and then I can give a belief for more things, that's more or less how I usually try to learn the things, because you can't try out everything obviously, and there are some things that are theoretical and it's not possible to try them out. But I usually -- if something must work, I want to see it working, not just read aloud, “It has worked somewhere, some why.” No, I want to see it in my computer, because it's something that works, so--

**Hanieh:** But can you say how many hours do you spend for this course, per week? As average.
Interviewee: The model based--? For a week, we have for a week like three hours of class and then we usually meet like five hours with the group depending on the obliques, I mean the first two weeks maybe we didn't meet, and two weeks [unintelligible 00:13:16] and then usually before the meetings, I try to spend from three to five hours thinking about what is going to happen in the meetings, because I need to -- the lessons, the lectures are 100% theoretical, so I need to try out at home what they have told us, so at the end would be five in the meeting and five more between the lessons and work in 10 hours a week.

Hanieh: 10 hours per week. Cool job. And during the project, or your learning, what did you use or which one do you think that were more useful to learn the concepts between the lectures, documents, tutorials, videos, discussions, with your group team teaching assistant, or which one do you think is more useful?

Interviewee: What do you mean for the obliques or in general?

Hanieh: General, in during the course, I mean those were the obliques and concepts.

Interviewee: The concepts that we learn -- For instance, during the first oblique, we learn a lot about the strategizer, how to create the canvas model, and then when we were meet with the group, thinking aloud about all this stuff and how to implement that into a real model is where we really understood something and start visualizing, "Okay, this could work, it has sense." Because at the beginning was really just read an example model from someone, that this somewhat related to business, and this business -- when they start talking about money and processes, I get somewhat lost because it's like, okay, I don't know how to rule our business because it's not my job.

So during these meetings, we discuss the things and try to - - okay, but if we put that, we need to change this or that and then we learn, obviously taking into account the material of the course and reading the slides again and looking into the examples provided, but for those theoretical parts of the beginning, the first way to learn about it was to meet with the group, that we were lucky because you need to have a good group to be able to do that. If the group is not willing to meet or not so participative, it's not possible to do that.

And with the second oblique, we learn -- I really enjoy webratio video tutorials, to me they are perfect, I haven't seen so good video tutorials ever for any of the tools that I have tried or whatever, the problem was that what we were asked to do and what the video tutorials so were totally different, but the video tutorials were great, because they were really easy to follow, well-structured, they explain everything, but the problem with a video tutorial is that it's not complete, they just give you one example.

And when you are looking the tutorial with the tool open in front of you, you want to click in that part to see -- show me that, click there, and that's not possible. But if you only have the full documentation of every aspect of the tool, written in text, it's not so easy to
understand the overall picture, like with three minutes video. So I think that both are necessary, and maybe with webratio we didn’t have this written explanation of all the single elements or features of the tool, but the video tutorials were great to me.

**Hanieh:** Well, it's cool then. Nice. So you think that -- actually you just told that videos are just recognizable and updated and short enough?

**Interviewee:** No, because we were using the mobile version. The mobile version was like two weeks -- was released two weeks before, or one month before we started, a lot of the videos were about the web version, not the mobile version, but some of the concepts were also valid. I mean, almost all of the concepts were also valid, but was not so clear for us, so we weren't sure if we can follow the web tutorial and if that part was going to be useful for our project or not, I mean when you are doing the backend, you don’t care if it’s going to end up in a web, in a mobile or whatever.

And they also updated the tool like two or three times while we were working, so I don't know if they were updated enough or not, I think that was good enough, I think yes, and also, when you are using a tool that is done by some community, I mean I haven’t paid for that, so if the tool gets updated, it gives me a really good feeling because I’m using something that someone else is taking care of in some part of the world right now. You are not using -- I mean, I have used sometimes for instance, for my Bachelor project, I have to use a game engine, so I need to look up for all the game engines on Google or whatever, and I end up using a game engine that the last commit was like one year before. So I was thinking, if something goes wrong, okay, I have all the source code, so I can do whatever I want, I could fix it. But nobody is taking care of me. I mean, if something goes wrong, I don’t have anybody to complain or to ask or to say, “Okay, what is this class? I don't understand this class. What is it doing, or what happens with this.”

So the feeling with webratio was totally different. I thought that if something happens, I can ask somebody. The problem is that somebody is going to take care about the tool or the IFML, but not about my oblique, or my particular need in a particular scenario, so I didn't even try to ask somebody of the web ratio community about how to connect to this specific database, because it's not something that they are willing to answer me. I mean, they are not there to do my work.

**Hanieh:** Do you think in that about the oblique, I mean to your assignments? The one and the second assignment. Could you just rate your level of understanding between 1 to 10? But about functional and the structural understanding. Do you feel that you have just control over all the functional and structural stuff or the things during the project?

**Interviewee:** Of the oblique that we deliver? You mean if I understand the whole oblique one that our group delivered?

**Hanieh:** One and two.
Interviewee: Yes. 10. 10 for both. Because we didn't try to divide the work in several -- I mean, we separate the work in working packages or something like that, and we work -- it's of the group in one specific part, but then we put all together, and when you try to split the work in several working packages, you need to have an overall picture of the project and to understand, because otherwise it's not going to work when you try to join all the parts together.

So what we did during the meetings was more or less the synchronization about all these individual parts. I mean, we take the whole project, see how to continue, see how to keep everything synchronized, divide some parts and then say, "Okay, you can start doing this, this and this, you can start doing this, this." And in two hours, we speak again, we talk again, and we put into common. So I think that for these obliques, I understood everything and was aware of every single change that was on in all of the parts of the oblique.

Hanień: Based on your report, you rate 10 for you, I mean when I saw that, wow, that is perfect. That was really good, actually, but during the project, or just trying to implement the project, about -- Could you explain to me shortly how was your problem-solving process, when you were faced to some problem, and the web ratio, how you managed or how you just tried to solve that.

Interviewee: With web ratio? The first problem that I had with web ratio was, okay, we are going to create an Android app for you, I know how to code Android apps, I haven't seen the Android app source code with web ratio, and it should be somewhere, maybe they put into a private folder and then delete it, but I haven't seen it. I didn't like that because I need to understand the logical process that is going behind, because when some reference is not working from one model to another for instance, the only way to fix it is think like the computer is thinking, and do what the computer is going to do because at the end the computer is going to take the file and say, "Okay, the file should be there, is there? No. Never." So why is it not there? Why is it happening? So it was really difficult to me to follow up the process with web ratio.

I mean the model, when I worked with models, I usually use EMF, and at the end you can open the EMF model with some editor or with, at the end, they put a graphical representation for that model or you can create your own editors, whatever. But you are [unintelligible 00:24:42] right click, see the text version of my model, and I know that there is nothing behind that, that's the model, that's the text version of the model, it's what is going to be understood by the machine, and transfer into the graphical model, whatever. And that was really difficult to do with web ratio. I usually work with Eclipse. And this web ratio was like, "We are not Eclipse. We are going to create our own views. I don't let you to use their project explorer, for instance, to see all the files." I don't know how all the information we put into that web ratio project is a structure, because at the end, when your structure information usually have like a hierarchy with several folders, the files, this file is for this, this folder is for that, and that's what's not something public
in webratio that the user is not aware of what is happening, and you have this multiple levels, and less levels that -- I mean, I was sometimes trying to do double-click somewhere random to see if something happens and if there is a deeper level inside, because it's not clear, the hierarchy to me. So that was most of the annoying part of the web ratio because when something was going wrong, we don't know. I mean I had problems with this computer because when I tried to open the Android emulator with the app, it didn't appear and some message appeared, and I said, okay, if they are opening in a web page something, they have a web provider, a web server, so I'm going to check if the ports are open and things like that.

But it was not easy to follow up what was happening in behind. I wasn't able to fix that, I just changed to another laptop, but, I mean, when we were using, for instance, the emulator and trying things out, I need to open the developer console and check the messages that are going to the server and back to check the errors, and to me, it's not possible to get, to hide, I mean we are modeling, not coding, if I try to contact a web service, and the web service is not answering, and the Java Script or the -- not Java Script, the output console of the browser gives me an error message, that's code because it's an error message rise from the code and it's saying something like, “[unintelligible 00:27:44] exception, you'll point the exception, whatever, whatever.”

But it's something that I want to be aware of because otherwise it's not possible to fix the problems, so what we did was try to know what was happening in behind because at the end, they can call things whatever they want, but you have files, you have languages and computers doing the same as always.

They can put a graphical notation over it, or do whatever they want, but at the end, all the models are text file with text, with an XML that needs to be interpreted, and if a letter is missing, it's going to fail, so that's what is more or less what we try to follow, to see what was happening. And also with the example projects, the example projects were really good, but one of the problems was I open the example project, and they have one pointer to a backend URL, and I was like two hours looking for that backend URL in all the files and videos and whatever, and it didn't appear, and I was sure that, okay, the backend URL at the end, it's a property that has to be appointed a URL to some server. I don't know if it could be local host or in another part, I don't care. But it needs to be a URL because it's how things work in computer science. It's not possible to reinvent something new.

I mean, they can't do things like, okay, I put the property, backend URL, but there needs to be a mapping somewhere inside that project that says, “This backend URL is this IP.” Because it needs to be an IP. It's not possible to contact to another computer without the IP. It could be behind, below, or hiding somewhere, and at the end what we did was, okay, open the project from the explorer, and with the text seeker, we browse all the files, automatically of course, not manually, looking for WWW, for instance, and at the end, it appear, it appear and it was a URL. But was really difficult to find that because it was like hidden. Not easy to find. So we used those projects and was really useful
because we're working projects with some difficult. They were big enough, not only [unintelligible 00:30:34] and that's all, so it was really good to follow up, and to see how are they doing these things, and we found some parts that were not so clear. I mean, the log in for instance, when you put the box log in from the webrtc implementation of the IFML, you are not sure if that log in, it's going to ask for your web service towards the log in service, or you should also put this request, this HTTP request, because it's not clear from that box what it's going to do. That box. And if you want to access to another database, to do the log in, what happens?

You are not able to use that log in box you need to do, so at the end, I was expecting, okay, it's going to contact to a web server, where are my request? I want to see the request. I don't like to have, no, there is no request, just this box, and it's going to infer magically, which service do you want? Because there is no magic at the end, so that was more or less what we tried to do.

Hanieh: Now we just want to know something about, I mean, to know, or do you see some relationship between assignment one and two? If the assignment one was useful to help you in different perspective, in different views to get better understanding or to do the implementation step, the assignment together, I mean, but now I can just call you one by one, the modelings language you have used or implemented, assignment one, and you can just tell me how this one is related to the--

Interviewee: During the development?

Hanieh: Yes. So the first one is business model canvas or value proposition canvas.

Interviewee: To me that model enable us to have the overall picture of the app that we were going to build, because at the beginning, we were not sure if we were going to sell the app, the sensors, a combination of sensor plus app, so with this canvas, we started to more or less realize, "Okay, there is people involved, what we are going to do is to sell just the app, the sensors are going to be produced by other companies or other people, it's not our business, so we try to outline more or less what we were going to develop in further steps, so with that canvas, we get an overall picture, but nothing about exactly how to code that or how to implement that, but at least we knew that we were looking for an Android application, not the source code for a sensor, for instance.

Hanieh: And the next was myServiceFellow or experiences?

Interviewee: That was the part where we try other sensors. It's always good to try other apps, because you want to do at least as much as good as they have done, and obviously, better, even better, and we were able to try this SunSense — I don't remember the name. The one that used to put in your clothes, that was not really helpful because if we were going to develop an Android app, even the sensor itself is not good but we did it also, and the other one wasn't working for us in our mobile phones, either the sensor was failing or the app was crashing, but we were able to look at it in another
student smartphone, I think it’s good to check this kind of things, to check the competency, what other people have done, looking for something similar as you. I didn't really like the app, because I remember it like too fancy and too superb, with a lot of colors and like a car, but at the end if you are going to show data, you don't need to put extra things rather than the data or things that helps you to understand the data, but not a static picture of something, things like that.

And the ExperienceFellow, I suppose that it is used to gather all the comments from several sources, and then do some kind of stuff with them, but I wasn't able to check comments from others, from my ExperienceFellow app, I don't know if I was supposed to do that or not, or was the teacher, the professor, the ones who was looking at all the data, so at the end I just evaluate the sensor and the app, and put the comments into the ExperienceFellow, but it wasn't helpful to me to use the ExperienceFellow, was helpful to evaluate the -- not the sensor, the app, to see, okay, they have done this, this and this, so we can take that as starting point, and try to improve it.

Hanieh: So next was smaply personal stakeholders’ maps or journey maps.

Interviewee: When we started that part, we need to come back to the canvas model to modify, but at the end it's what is usually done in these practices, I mean we need to iterate and to modify things, it's something we are used to do that, you start doing further steps and then something happens, you need to come back, modify, and keep looking until everything goes, okay, I had previous experience using this persona idea, but it was totally focused on user experience, so what we did -- the code was I also, because it's people or in Spanish, so I remember that really well, so what we did for that user experience evaluation was, okay, you need to define a persona, and then it's like a kind of user, more or less what we have done here, and then try to, like here, feel what the person is feeling or is going to do, and try to put you in their shoes, and follow -- put into their point of view. But then, there was no, I mean that part of the personas was similar, but then with the stakeholder maps and the journey maps, was not so similar as what we did before, because what we did before was something like, okay, this is the persona, the persona needs this, this and this, so the next step for us was I'm going to create some mock ups to fulfill their needs.

And in this part was like further defining the persona, the journey map, I mean, during that part, we weren't thinking really in the app, or modifying our product or app, rather than trying to explain how our app was going to adapt to that person, I mean when I did that previously, I was trying to create the mock ups for that persona, and to say, okay, if this persona is a sun lover, what they need to check or to see in the first screen is how much sun is around here for instance, if this persona hates the sun, needs to check, where are the shades around him for instance, but what we did during this course was, okay, do the journey maps and explain how this persona used the app, but was too much theoretical to me, because we were defining the app yet as we were doing that, what I did before was, okay, this is my app, my intended app, and now I'm going to try to
these personas, and then modify it, refine the app, but during this experience we didn't have a clear idea of the app, so wasn't possible to refine because there wasn't anything.

**Hanieh:** And next was BPMN. Define a little.

**Interviewee:** With the BPMN, we had some problems because we try to create a perfect model, totally compliant with all the standards about BPMN, and we had a lot of information about BPMN, and it's not so easy to create the perfect model in BPMN because we are not experts, obviously, so we lost too much time trying to be really perfect with that model, and at the end, it's just a model, if it helps you to understand better the domain, I mean for instance, today I have seen, in one of the example exams, some mistakes in those BPMN models and nothing happens, at the end, it's something too abstract and thinking a better way about the problem, and to help you to solve the problem, but we were stuck for hours trying to model, how to ask for a log in to the user or you are not logged, registered into the system, then I'm going to ask you for data to register and if you are registered I'm going to show you the first screen.

So we were stuck for hours with that problem because we were trying to connect all of this steps with lines because I think it's how it's supposed to be, you need to have one line from each step to the next, and at the end the solution that we saw in some web pages or the one that I have seen today, one of the exams, was like relaxed this notation and say, just model something more or less, because it's going to help you understand better what's happening, it's not a model that you execute, it doesn't need to be 100% perfect, if there is a mistake, when someone looks at it, you may think, okay, there is a mistake, but I understand the overall idea, so that was our problem with this BPMN model.

**Hanieh:** Smart feedback actually. So the next one is UML information model, or if you can you can just have a UML use case or used in one.

**Interviewee:** I don't remember what we did for the--

**Hanieh:** In the UML uses stories or cases--

**Interviewee:** The UML information model, what we did was the class diagram, I think, we were totally thinking in code, we put a lot of code-related things, nobody ever -- I mean, we haven't used that after that, because we were thinking if I'm going to code this app, what I'm going to need? What classes do I need? But at the end we didn't code that app. So the abstraction level was not good enough for us. We were focusing too much in what classes I'm going to need, and at the end, we didn't need that much detail that we put into the class diagram, and with the user stories and use cases, in that part, I think that's really useful to realize what app are you doing and what is going to happen in your app because at the end it's of the user stories and user cases is some of the functionality that your app is going to have, and was more or less that the first moment where we put into our paper the functionality that the app was going to have, up to that
point, all was like, okay, we are going to target surfers and sport people, and we are
go to make millions of money, but at that point, we say, okay, I need this, this and
this features, and someone is going to do it, so you are much more specific about that
and you start doing exact, okay, this feature, this feature and this feature, in the canvas
model for instance, we talk about services, and we are going to have paid services, and
premium services and the main specific services, but which one? Which services? At
the end, when you start saying, okay, I'm going to have a service to check how many
radiation I received that day. You have something that you can touch and you can
implement, but the first steps were really vague about the -- not the implementation, we
were just giving ideas like brainstorming but not something concrete. So after that steps,
we thought that, "Okay, this is something more concrete and we can implement this if
we want, and also with the mock ups."

At the end the mock ups is what gives you, at least to me, the idea of what is going in
the app, what is happening in the app and what's going to be able to do, or not, because
if you have a button to do something, it's going to do that, and they are not several
services or services, you have service one, two and three, and if it's three, it's three, not
anymore. So in that part, we start visualizing the product better than before.

Hanieh: And the next was like non-functional requirements, and I mean the planning
[unintelligible 00:46:49] plan or the process.

Interviewee: At the end the planning, as we were meeting too much, we didn't really
use a Symphonical board to do the planning, because what's easier to us at the end.
The problem should drive the solution, I mean, I don't like to be forced to use
Symphonical, we use Viber for instance, because I have in my cellphone and I say,
"Okay, hey, man, what are you doing with that model? This or that?" It's easier to me to
use that tool rather than the other, so we didn't follow the Symphonical board and
everything, because we were meeting not every day but every week, so we didn't need
to use these tools.

Hanieh: What about the implementation, did you have any sprint, I mean did you guys
define some sprint or the level one, two or three, and try to--

Interviewee: You mean for the second?

Hanieh: Yes, I mean in the scrum model they try to define some [unintelligible
00:48:05]

Interviewee: Yes, as we were in modeling, I mean, you mean if we create a scrum plan
to create the obliques, to follow with the obliques?

Hanieh: Well, I mean really a scrum plan, okay, this is a scrum plan, everybody attend, but what we did when we meet was,
"Where are we? What have we done so far? What is left? And what are the next steps?"
So when we meet I think in all the meetings, with the board, make a picture of our
project, where are we, what's left, when is the deadline, of course, and who is going to
do each part, so at the end we have the picture and say, “Okay, this part to you, this to you.” And in three hours, we put together and deliver. [laughs]

**Hanieh:** Cool. The next question. Just more about the implementation organization part. I want to know if you have used one of these [unintelligible 00:49:10] that we discussed about, used as input here. I mean in the user interface frontend or database or the connection between the frontend, the backend or the business logic process, did you use one of these as an input here?

**Interviewee:** Here would be the webratio, the second oblique. Obviously, with the mock ups, the balsamic mock ups were the only input to create the user interface, we need to change some parts because it was not easy to do that with the webratio, so we just modify them or whatever, and at the end our database was not so big, but if we were -- I mean, we didn't use the class diagram to create the database because what we previously did with the class diagram has nothing to do with the rest of the tool because we were thinking in what are we going to code instead of how to model this app at a high level, to create the connections between frontend and backend, I think that we follow what we previously did with the business process, more or less, because we only create one business process model and not all of the parts were there but was helpful to create that part. And to create the business logic, I think that we didn't use, I mean at the end, yes, well, maybe we didn't use one of the models like, “Okay, take this model and now we are going to do this using that model.” But obviously what we apply here was a direct consequence of what we have previously discussed with all of these models.

I think that's more or less the idea. We had an understanding and a common point about what the app was going to be like, and what the app should do so we use that information that was somewhat formalizing in those models.

**Hanieh:** Do you think that you were able -- I mean the implementation of the application by using IFML and webratio, I mean both learning and implementation, during the second assignment, it was just learn and at the same time just implementing the project, do you think that you were able to do that at the same level without assignment one?

**Interviewee:** No. Impossible. Impossible because when we get to that implementation, and learning of IFML process, we already have a project and a common idea between the group and we were thinking in, okay, our app, or view, or service, or app, this is going to do this, this, and that, and if at that point someone says or tells you, “Okay, the app is going to do this, this and that, it's not the same as having to spend one month thinking about that idea, that app.” So I think that is necessary, because the second oblique was not easy, but at least we had something that was from us to start over, so we didn't doubt about if this service should do this, or that, because that was up to us what the app was going to be so I think it's necessary if we just apply to some project that is not something that we know and that we have spent time trying to learn and to understand how it's going to be, it's not so easy to understand the second part.
Hanief: So we are just somehow in the method, I mean the method of the teaching, or teaching methods. What do you think about the teaching methods? I mean about the - or by focusing on the model based system development, the methodologies and the languages that you have used. What are the things about the teaching methods?

Interviewee: What do you mean, of the course? The lectures are highly theoretical, maybe too much, because there are a lot of technologies, a lot of different approaches, a lot of acronyms, and at the end it's easy to get lost, and to say, “Okay, I will read the slides later.” Because there is too much said about how to create a model, how to model this, that and that, but if you are not modeling that at the same time, it's just, okay, you listen to everything, but unless you try it out it's not so easy, and then some of the practical because we were supposed to have two hours of lecture and then one hour of practice, not every day but some of the days was more or less like this, but some of the practical parts were not so good because it's like, “Okay, this is a tool, the screen is square, and you have buttons and when you click the button, something happens.” I can figure that out. It's not so -- maybe I need to spend two or three hours with the tool, and then I can have this part and ask for things and say, “Okay, I know that there are buttons and you can click the buttons and you can change the colors of the notes in the canvas, but how to do this or how to do that?”

The tools that we have used are really nice and really easy to use. And to start with is really -- you have three buttons, just click them and you will figure out what's happening, so I think that practical part should be done after, we first try out, start doing something, and then ask. With the web ratio, with your practical parts was easier because we had the problem and we have tried to do something, wasn't working, so we had a lot of things to ask you and even we need extra classes to ask for those things, but if there's a simple tool, really easy to use, really nice, that we haven't ever used, there is no need for an introductory lesson about that tool, at least to this level of experience, I mean if there are still from other domains, maybe they need to learn how to use that but I didn't learn anything from how to use the canvas. You can drag and drop, of course. I can try that out and the x is going to delete and to close. It's something logical.

Hanief: But do you think that during the course you have been motivated from the course manager or the teaching assistants to just attend the course or just continue and keep working. Have you got any motivations?

Interviewee: To attend the course?

Hanief: Yes, and to just keep working with the--

Interviewee: To me, the key point is the obliques. I mean first day, first oblique. It's how it should work because the first two or three weeks that we didn't have obliques was like, “Okay, I come here, they talk to me about models, models, more models, MDD, MDD, a lot of acronyms.” And it's okay but you just listen, listen, listen but you don't
know if you have learned or not how to do that. But then when you start with the first oblique, you say, “Okay, he said something about in the I don't know what, let's go back, review that, and start applying.” So to me the keypoint and the connection, what makes the course go through, is the obliques.

Hanieh: The obliques are more, maybe useful, than the -- I cannot say useful, but more motivated or can just motivate you more than the course instructor or the teaching assistants. Just working with the oblique for you was more interesting.

Interviewee: I like more the practical part so at the end, the obliques and the teaching assistants helping us with the obliques, obviously, and are explaining things that were going to be useful for the obliques, but if there is no oblique, I don't read slides until the day before the exam, so I need to work on that and I think that that's the part that makes you understand what's happening.

Hanieh: And the next is do you think that you will use, the methodologies and technologies later? Work or--

Interviewee: I think yes, but because I'm doing my PhD at something highly related to models, so I mean for instance, we usually do the graphical editors using EMF, and we have seen a lot of times and there are more things like [unintelligible 00:59:52] Graffiti, Sirius, but we haven't ever tried any of them because we were used to just DMF, we start with EMF, we learned how to deal with EMF, that is not easy at all. And at the end, we say, “Why are we going to change? It's not necessary to change.” If we are using the program for instance with Sirius, is that, we create a graphical model, release, in five minutes you have a graphical model but it's not so easy with EMF, but I haven't seen the code of that graphical editor. It's something that is being interpreted by some plug-in at the front time so I need the code and be able to modify it in order to be useful to me, but I think that what we have learned is useful to me and I'm going to use it or at least to suffer it more times in my life. [laughs]

Hanieh: Of course it's, I mean, use date for PhD or -- I guess we have answer with these questions already. So at least it will be two questions, first the difficulty level of the course between 1 and 10.

Interviewee: I don't know, we need to see the exam, obviously, the course is really broad, there are a lot of topics, but when we present the oblique, everything is okay, so with the first oblique, first course that I took in this university was like, it needs to be perfect, I need to work more and more and fix this and that, but then after that presentation and when we saw other groups' presentations or with the second oblique, I think that during the first oblique, each of the groups were supposed to talk about one specific part of the oblique before the final delivery, so with that I lowered the difficulty of the course, because I saw that we were learning and nothing -- it didn't have anything when things weren't perfect, you do as much as you can, and then present that and it's enough. And there is no grades or no--
But I need to see the exam obviously, I mean I have seen the exam, I have seen five year exams and all of them are the same, and it's the same that we have done already, so I suppose that the course is not so difficult, but you need to attend and to follow the course obviously if you don't come to the lectures and you don't do the obliques or don't spend time with the obliques, it's going to be really difficult to pass the course because the topic is difficult, and not so easy to guess, I mean it's not something that, “I'm not sure, I think this, this.” No. Or you attend and try it out, it's not easy to follow. So I think you want a number. The difficulty level of the course, I don't know. Let's put an eight.

_Hanieh:_ Eight? I've got one three, last time. [laughs]

_Interviewee:_ I don't know how to measure the difficulty of the course, if you mean like to pass the course, maybe it's a three or a five, I haven't done the exam but if you want to Master what have been said in this course, it's really difficult.

_Hanieh:_ But the thing that's actually more interesting or I as a researcher, I mean get different answer. For me it's more interesting, there's one three, one eight, one five. One one, or so it will be fun to see how is it or [unintelligible 01:05:11]

_Interviewee:_ Usually what happens to me also with exams and things like that, is that I start studying or working on that and the week before when it's something really big and important, you think, "I don't know anything, it's not going to work", but I think that you learn and you understand so well the topic that you only focus in those five things that you don't know how work, but the course was really broad and to understand everything is difficult. I mean even to read everything, it's like 1000 slides and every 10 slides, you have a link to a book of 100 pages, so whoever says this is easy is because he's not reading all of that parts obviously.

_Hanieh:_ And the last is -- the last question question. If you have any comment or feedback, those on the course, and the materials, I mean, the documents that you used, the instruction sheets, do you have anything or any feedbacks on how we can improve this part or total on the course, any comment or feedback on it.

_Interviewee:_ You mean for the material?

_Hanieh:_ Yes, both the materials and both on the course, I mean generally.

_Interviewee:_ I'll ask about that. The material is good, it's too much. It's too much and it's too complex to understand in one picture, I mean there is too much things, but I think that they are well-structured and it should be, it's not something that can be drowned in one page and say, “Here is the course, understand it.” So I also like to have more material than needed. I mean, if I only have one small slides outlining the topic, then if I try to follow that one year later or at my home, it is more difficult than if you have a lot of
things and then you just read some of the things, what you think that are more important but I prefer to have more slides than I need.

So I think that part is okay and the obliques were also easy to follow because we had the introduction of the oblique and then all the steps that we should follow, more or less a structure, so I think that I don't have problems with the material, and also I like the lectors from other universities that came to, because the topics were related and were nice to have people in other parts of the world doing things the same or doing things related and ask their experience. So I enjoyed the course.

Hanieh: Cool. That was the last actually, and thank you.

Interviewee: Too long.

[END OF AUDIO 01:09:04]

[end of audio 01:09:06]