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Object Modeling and Building Information Modeling

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Object Modeling and Building Information Modeling

Objektmodellering og bygningsinformasjonsmodellering

BY:

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SUMMARY:

The main part of this thesis is an online course (Small Private Online Course) entitled *"Introduction to Object Modeling and Building Information Modeling"*. This supplementary report clarifies the choices made in the process of developing the course.

The course examines the basic concepts of object modeling, modeling techniques and a modeling language (UML). Further, building information modeling (BIM) is presented as a modeling process, and the object modeling concepts in the BIM software Autodesk Revit are examined.

Object modeling is a natural way for people to make sense of phenomena in the physical world. BIM is a "new" way to model, and successful modeling requires a basic understanding of how models are created by humans. The course aims to give students an introduction on how to make useful and understandable models.

To give students an understanding of how these processes work, a mindset has been established for the course. It is inspired by Karl Popper's theory "*The Three Worlds of Knowledge*" and Terje Totland's modeling processes, described in his doctoral thesis *"Modeling as a Means to Support Human Sense-making and Communication in Organizations"*.

The course is available at: http://folk.ntnu.no/tgs/IntroductionToOMandBIM/

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for

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Object Modeling and Building Information Modeling

Background

Philosophers have for millennia pursued understanding the world. Science has divided the world in domains suitable for classification and scholarly study. Common concepts and terminology is necessary for fertile human communication.

Object modeling is a method for understanding and describing the world in terms of objects and relations. It supports creation and visualization of mental models of a system or problem domain. Building information modeling (BIM) is a relatively new notion in the AEC industry, and introduces a new way of thinking. Successful modeling requires a basic understanding of how humans and computers operate models.

Approach

The students will study and discuss the background and basics of object modeling, including various object modeling techniques.

The philosopher Karl Popper's theory of "The Three Worlds of Knowledge" constitute a mindset for understanding the mental modeling process, and how BIM is related.

The Object Modeling approach with application to BIM will be presented as a Small Private Online Course (SPOC).

Delivery

The students will deliver an interactive online course (SPOC) and an accompanying report.

The thesis is to be delivered to the Department of Structural Engineering within June 10th 2016

Trondheim, January 25th 2016

Tor G. Syvertsen
Supervisor

Preface

This is a master thesis written by Hege Auråen and Hanne Gjemdal at the Department of Structural Engineering at the Norwegian University of Science and Technology in the spring of 2016, with Tor Guttorm Syvertsen as supervisor. We are students from the ICT and Structural Engineering program and therefore we wanted a master thesis that incorporated both disciplines, which "*Object Modeling and Building Information Modeling*" does.

This master thesis on object modeling and building information modeling (BIM) has been a "learning by teaching" experience. The main delivery is a Small Private Online Course (SPOC) accompanied by this summary report.

We have divided the topics of the course between the two of us, however as we have worked closely we have both been involved in the development of all topics.

We would like to thank Tor Guttorm Syvertsen for great guidance and space in his office, and Eirik Aasved Holst for valuable input on object modeling in Autodesk Revit.

Trondheim, June 8, 2016

Hege Auråen

Hanne Gjemdal

Abstract

The main part of this thesis is an online course (Small Private Online Course) entitled *"Introduction to Object Modeling and Building Information Modeling"*. This supplementary report clarifies the choices made in the process of developing the course.

The course examines the basic concepts of object modeling, modeling techniques and a modeling language (UML). Further, building information modeling (BIM) is presented as a modeling process, and the object modeling concepts in the BIM software Autodesk Revit are examined.

Object modeling is a natural way for people to make sense of phenomena in the physical world. BIM is a "new" way to model, and successful modeling requires a basic understanding of how models are created by humans. The course aims to give students an introduction on how to make useful and understandable models.

To give students an understanding of how these processes work, a mindset has been established for the course. It is inspired by Karl Popper's theory "*The Three Worlds of Knowledge*" and Terje Totland's modeling processes, described in his doctoral thesis *"Modeling as a Means to Support Human Sense-making and Communication in Organizations"*.

The course is available at: http://folk.ntnu.no/tgs/IntroductionToOMandBIM/

Sammendrag

Hoveddelen av denne masteroppgaven er et nettkurs (Lite Enkelt Interaktivt Kurs) med tittelen *"Introduction to Object Modeling and Building Information Modeling"*. Denne supplerende rapporten redegjør for de valg som er gjort i prosessen med å lage kurset.

Kurset tar for seg objektmodelleringsprinsipper, modelleringsteknikker og et modelleringsspråk (UML). Deretter presenteres BIM som en modelleringsprosess og en jevnføring av prinsippene for objektmodellering og for BIM-programvaren Autodesk Revit.

Objektmodellering er en naturlig måte for mennesker å forstå fenomener i den fysiske verden. Bygningsinformasjonsmodellering (BIM) er en "ny" måte å modellere på, og vellykket modellering krever en grunnleggende forståelse av hvordan modeller blir håndtert av mennesker. Kurset har som formål å gi studentene en innføring i hvordan en lager brukbare og forståelige modeller.

For å gi studentene en forståelse for hvordan disse prosessene fungerer, er det utformet et tankesett for kurset. Det er inspirert av Karl Poppers teori "*The Three Worlds of Knowledge*" og Terje Totlands modelleringsprosesser, beskrevet i hans doktoravhandling "*Modeling as a Means to Support Human Sense-making and Communication in Organizations*".

Kurset er tilgjengelig på: http://folk.ntnu.no/tgs/IntroductionToOMandBIM/

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Abbreviations and terminology

Abbreviation	Meaning
BIM	Building Information Modeling
BIM model	Building Information Model
AEC	Architecture, Engineering and Construction
SPOC	Small Private Online Course
UML	Unified Modeling Language
E-learning	Electronic Educational Technology (Learning by means of digital tutoring aids)

Table 1

1 Introduction

Object modeling is considered a way for humans to make sense of the world surrounding them. This thesis elaborates the object modeling process and relates it to BIM. Common understanding is crucial for successful application of BIM in the Architecture, Engineering and Construction (AEC) industry. The main part of this master thesis is a SPOC comprising two main topics, “Object Modeling and its Purpose” and “Building Information Modeling”.

BIM is, simply put, the means by which everyone can understand a building through the use of a digital model. BIM has entered the stage in the AEC industry and several building owners require BIM compulsory in building projects.

The mindset for this thesis has been inspired from the philosopher Karl Popper’s theory “*The Three Worlds of Knowledge*” [1] and the modeling process from Terje Totland’s doctoral thesis “*Modeling as a Means to Support Human Sense-making and Communication in Organizations*” [2]. This mindset presents three worlds, and shows that object modeling and conception of the real world is done on an individual level. When creating a BIM model, humans try to express their conception of a problem and corresponding solution in a representation external to their minds. With respect to communication and collaboration the crucial point is shared mental models among the participants. BIM software is, simply put, a database with a graphical interface that works as a modeling language. A BIM model or any kind model can’t be right or wrong, but it can be useful.

1.1 Background

Humans have always tried to narrate and understand the world. Therefore, the world has been divided into domains suitable for classification and scholarly study. Effective communication requires common terminology and concepts. Object modeling is a method for understanding and describing the world in terms of objects and relations, and it supports creation and visualization of mental models of a system or problem domain.

BIM is a relatively new notion in the AEC industry, and introduces a “new way” of thinking. The Norwegian AEC industry is still not entirely converted to using BIM, though it is inevitable that BIM is here to stay.

1.2 Target group

The target group of the SPOC “*Introduction to Object Modeling and Building Information Modeling*” are students enrolled in an AEC engineering program, though the course is open for anyone who find it interesting. The course aims to teach students about object modeling and how this is applied in BIM, to make useful models. English has been chosen as the course language in order to expand the target group.

2 The SPOC *"Introduction to Object Modeling and Building Information Modeling"*

A SPOC is a private course that is made for a smaller group and is sometimes costly for the students. A SPOC combines online resources and technology with personal engagement between the teacher and the students, e.g. instant feedback during the course. Research has shown improved learning and student outcomes using the SPOC approach [3].

2.1 Aims and objectives

The aim of the course *"Introduction to Object Modeling and Building Information Modeling"* is that the students learn what object modeling is, how it works, and how it is adopted in BIM. Emphasis is placed on understanding the modeling process. After completing the course, the students should be able to

- Understand the modeling process
- Understand object modeling and BIM in the context of Karl Popper's theory *"The Three Worlds of Knowledge"*
- Create useful object models
- Understand how object modeling elements are used in BIM

2.2 Structure

The course comprises an introduction, two modules, a midterm exam, quizzes and a final exam. The introduction presents the mindset that has been created for the course. The two modules of the course are "Object Modeling and its Purpose" and "Building Information Modeling", with their respective topics, see table 2.

Introduction
Karl Popper's theory "*The Three Worlds of Knowledge*"
Models and modeling
Module 1: Object Modeling and its Purpose
History of object classification
Concepts of object modeling
Object modeling aids
Module 2: Building Information Modeling
History and background of BIM
BIM models and BIM
Object modeling concepts in BIM

Table 2: SPOC structure

The layout has an intuitive structure, such as going top-down in menus, to show the recommended path of the course. The path is not locked and the students are free to choose the order that best fits their learning experience. Resources and further readings are available in the course menu bar in the topics where resources have been used and further reading is beneficial for the student.

Assessment and feedback

After each topic there is a quiz with a few questions to make sure the student has paid attention and to increase the learning experience. Between the first and second module there is a midterm exam, and after both modules are completed there is a final exam. These assessments are used to test the students and the results give an

indication of how much they have learned. After each assessment, there is an option to review the results. This provides instant feedback.

2.3 Academic content

The mindset for the SPOC is based on Karl Popper's theory "*The Three Worlds of Knowledge*", how these worlds are connected to object modeling and BIM, see figure 1, and the process of modeling, see figure 2. During the path of the course the introduced topics are connected to the mindset, and their role in the three worlds of knowledge are accounted for. The modeling process is explained by applying the theory of [1] to the modeling processes in [2].

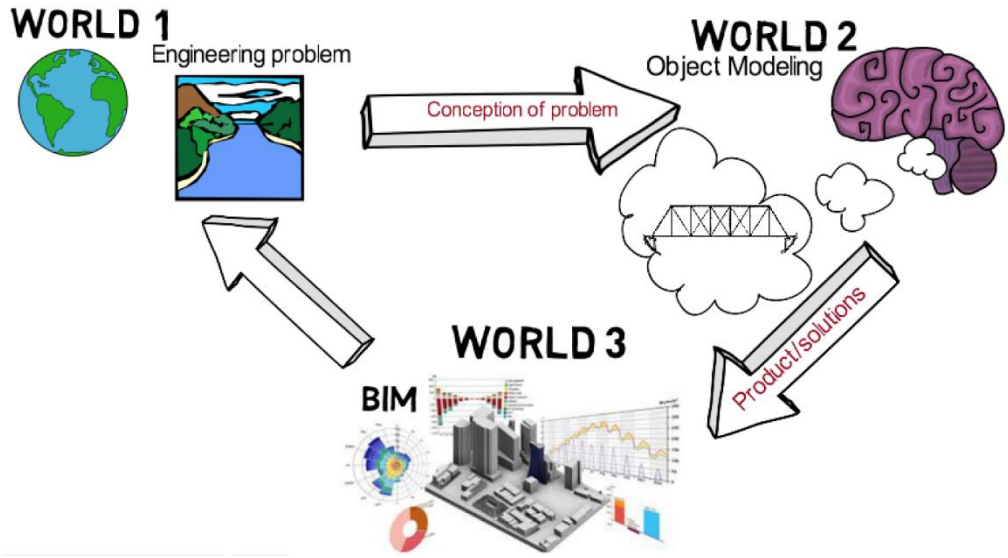

Figure 1: Thesis mindset. The Three Worlds of Knowledge

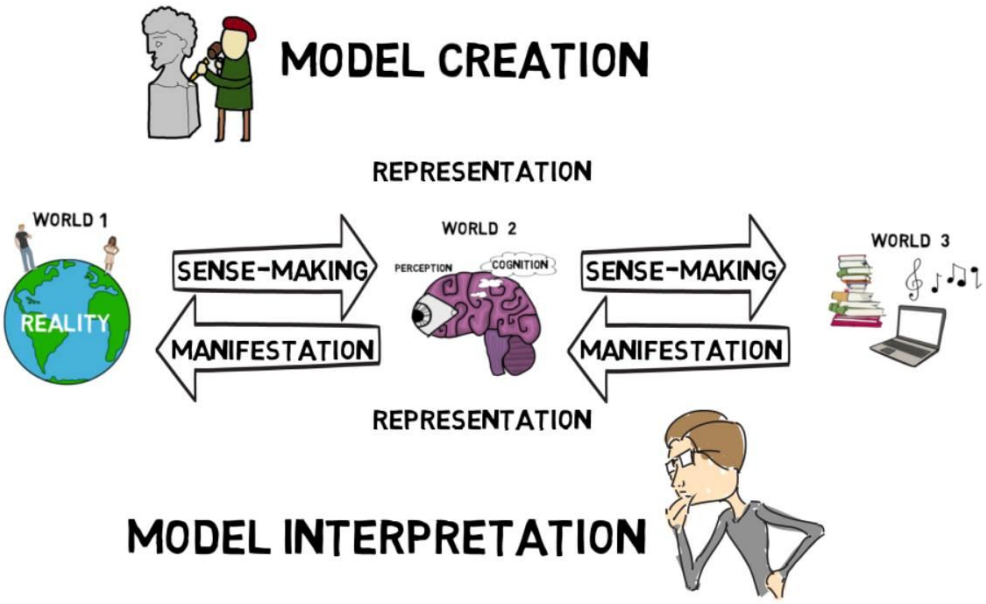

Figure 2: Thesis mindset. Modeling processes

The "Object Modeling and its Purpose" module

The topics of the first module "Object Modeling and its Purpose" are presented in table 2. The history of object classification is a part of the course to create a backdrop for object modeling.

The concepts of object modeling presented in the course are:

- Class and Object
- Association and Link
- Inheritance
- Aggregation
- Multiplicity

These concepts are essential in object modeling, and are prerequisites for the BIM module. Encapsulation and abstraction are not presented because these concepts are considered programming techniques, which are outside the scope of the SPOC.

The object modeling aids that are presented in the course are three modeling techniques and a modeling language.

The modeling techniques are:

- James Rumbaugh's "Object Modeling Technique"
- Grady Booch's technique
- Ivar Jacobson's "Object Oriented Software Engineering"

The modeling techniques are presented in the course to aid the student to start the mental process of object modeling. The techniques are presented very briefly with references to further reading for interested students. This is done because the techniques are software engineering techniques, which are outside the scope of the course.

The modeling language UML, is presented to enable visualization of the mental process. In the SPOC a use case, sequence and class diagram are presented together with an illustrated example. It is excessive to show how *all* UML diagrams are made. Therefore, the mentioned diagrams are seen as sufficient for the purpose of the SPOC.

The "Building Information Modeling" module

The topics of the module "Building Information Modeling" are shown in table 2. The first topic introduces the module with the history and background of BIM.

BIM models and BIM are then explained with regards to the modeling mindset from the introduction.

Object modeling as a thought process is compared with how object modeling is applied to Revit. This topic aims to show how object modeling and BIM are connected. The concepts of object modeling are presented and investigated in Revit, and explain which concepts that are in both object modeling and Revit, and which are not.

2.4 Teaching philosophy and guidelines

The design of the SPOC is based upon own experiences and reflections. Combined with these experiences, heutagogy was chosen as a learning philosophy, as the SPOC is made for adults. Heutagogy is self-determined learning and has roots in andragogy, which is the theory and practice of adult learning. It puts the learner in the center,

and the approach is particularly suitable for E-learning [4]. Based on this, a few guidelines were created for the course:

Academic content

The academic content in the course should be relevant to the topics and should captivate the student's interest.

Interactivity

The students should be involved in the learning experience. This is done through quizzes and interactive elements in the course pages, for example hover states on buttons, or showing new elements in the course page when clicking on some element.

Intuitive design

The course design should be intuitive for students when it comes to the path of the course and the interactive elements in the course pages.

Multimedia

The course should include multimedia such as animations, YouTube videos and audio to capture the student's interest and attention, to make the learning experience effective.

3 Software

To be able to make a SPOC, an E-learning authoring tool is necessary. E-learning authoring tool means a kind of software that enables making a course that can be published online.

For the SPOC in this thesis it was important that the software included a quizzing function. In the search for E-learning software, different kinds of software were tested or examined, see table 3.

The criteria made for the software are as follows:

- Easy to use for the teacher (course developer)
- Easy to use for the student
- Inexpensive
- Quiz and exam functions
- Possibility for animations and interactivity

E-learning software	***Cost***	***Comment***
Articulate Storyline 2	License fee	This is a software that is downloaded on the computer. The design tool is similar to Microsoft Office applications and is therefore familiar and easy to use. Articulate Storyline 2 is the newest version of Articulate Storyline.
Articulate Storyline 1	License fee. There exists a software license from 2014 on the institute. This license cannot be used for Articulate Storyline 2.	The older version of Articulate Storyline. For the purpose of the SPOC in this thesis, there were no remarkable differences between the two versions [6].
Udutu	Monthly fee	This is a web based course authoring and learning management system. The design tool was not as intuitive as Articulate Storyline. [7]
Open learning	Free	This is a web based online course generator. This online learning platform also provides many free online courses. The design tool was not too intuitive. When testing the courses made with this tool, it seemed old fashioned. [8]

Table 3: E-learning software

The master thesis "*Innføring i digital samprosjektering*" (Introduction to concurrent engineering) [5] was conducted for the same department as this thesis and consisted of a SPOC. A trial version of Articulate Storyline 2 had performed well according to the criteria. The Departmental license for Articulate Storyline 1 was still valid, and therefore Articulate Storyline 1 became an easy choice.

In the guidelines for the SPOC, see section 2.4, it is stated that multimedia should be used for capturing the interest and attention of the students. Other than using multimedia like YouTube and audio, that does not require any special kind of software, there was a need for an animation software to follow the guidelines for the course. Luis and Storødegård [5] used an animation software called Sparkol VideoScribe to make animations for their SPOC. Sparkol VideoScribe is a whiteboard animation tool. After taking their course, the experience from watching the animations and the experiences from testing the software was good. Therefore, choosing Sparkol VideoScribe for animations became an easy choice.

4 Reflection

> "*If I had an hour to solve a problem I'd spend 55 minutes thinking about the problem and 5 minutes thinking about solutions.*"
>
> — Albert Einstein (1879-1955)

4.1 Experiences and challenges

During the work on the thesis we have had challenges and gained valuable knowledge and experience. Creating a SPOC has been both exciting and demanding since we had no prior experience with this. It has been a learning by doing experience.

The main challenges in our work process have been:

1. Creation of the problem statement
    - It was regularly adjusted
    - The problem statement was too ambitious with regards to academic content, and the course ended up going from four to two modules

2. Tankeheim ("Mind home")
    - This is a process of asking questions: for Whom, What, How, Why, When. The process is very simple, but requires hard thinking in order to succeed
    - Figuring out what to include in the course was a cumbersome process, and took longer than producing the course

3. Collaboration
    - Google Drive was a shared document repository
    - A common document structure facilitated shared editing of documents
    - Comprehensive topics resulted in somewhat confusing and large topics, and was split up into subtopics

4. Sparkol VideoScribe
    - Creating explanatory animations require skills and preparations of the course developer
    - The license was restricted to one user at a time

5. Articulate Storyline 1
    - Provided a lot of information on how to build a good E-learning course with their online community “E-learning heroes”.
    - It was not possible to only push updates to the Articulate Storyline file, so we could not work in the same file at the same time.

4.2 The road ahead

Further development of SPOC’s in ICT, Structural Engineering, Object Modeling and BIM can be pursued along several lines. Two obvious areas are:

A common platform for courses

Courses such as the SPOC in this thesis and in [5] could be made available to a broader audience on a web portal for object modeling and BIM, that also includes courses and relevant material from elsewhere on the web.

Online resources

The use of online courses, such as the SPOC in this thesis, can be used in the curriculum either as a substitute or in addition to the regular lectures. Extended use of digital resources and technologies requires a profound redesign of the entire system for engineering education.

5 References

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