Simple Mathematical Learning Objects

Development and evaluation of a standard
for mathematical learning objects

N I K L A S E K

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for mathematical learning objects

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Bachelor's Thesis in Media Technology (15 ECTS credits)
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Abstract

Today's world wide web is full of so called tutorials, articles intended to instruct the reader to learn something new. This is widely used for making instructive articles for software and coding techniques. But with the technology that exists today it is possible to create standards to describe the content in a more pedagogical way. For more than 10 years an idea of so called learning objects has been discussed. A learning object (LO) is a digital object that holds content. The idea is, in contrast to tutorials, to convey the material in a more pedagogical way with interactive exercises. The learning object should also be searchable, reusable and interoperable for the purpose of being used in various learning systems.

One of the most developed and open standard for doing just that is called Sharable Content Object Reference Model (SCORM). This is a standard that is made to make educational content sharable for all SCORM compatible learning systems. It has been developed into a complicated system that requires a team of professionals to implement.

In this thesis I researched the possibilities of creating a standard that focuses on mathematical content that is simpler and easier to implement than the SCORM standard. I also created a prototype of both a mathematical learning object and a learning management system to present the learning object in a Web browser. The prototypes was then tested by students who gave their opinions in a survey. This supported my theories on the prototypes simplicity and function as a tool for teaching and learning mathematical subjects.

Sammanfattning

Internet är idag fylld av så kallade tutorials, artiklar vars syfte är att instruera läsaren att lära sig ett visst ämne. Det är vanligt bland hemsidor som erbjuder kunskap om designtekniker i olika datorprogram och även kodningstekniker i olika datorspråk. Men med den utvecklade datorteknik som finns idag ges möjligheten att skapa standarder som beskriver sådant innehåll på ett mer pedagogiskt sätt. I över tio år har en idé om så kallade lärningsobjekt diskuterats. Ett lärningsobjekt (LO) är ett digitalt objekt som innehåller kunskapsinformation. Idén är, till skillnad ifrån tutorials, att framföra innehållet i en mer pedagogisk form med interaktiva övningar. Lärningsobjektet bör också vara sökbart, återanvändbart och interoperabelt i syfte att användas i flera lärningssystem.

En av de mest utvecklade öppna standarden för att göra just detta heter idag Sharable Content Object Reference Model (SCORM). Detta är en standard som skapades för att göra undervisningsmaterial delbart till alla lärningssystem kompatibla med SCORM. Standarden har utvecklats till ett komplicerat system som kräver ett team av professionella för att implementeras.

I det här examensarbetet granskar jag möjligheterna att skapa en standard för lärningsobjekt som fokuserar på matematiskt undervisningsmaterial och som är enklare och mindre komplicerad att implementera än standarden SCORM. Jag skapar även en prototyp för både matematiska lärningsobjekt och för ett lärningshanteringssystem som presenterar lärningsobjektet i en webbläsare. Prototyperna testades därefter av studenter som gav sina åsikter i en enkät. Detta understödde mina teorier om prototypernas enkelhet och funktion som verktyg i utbildning och lärande av matematiska ämnen.

Preface

This is a bachelor thesis in the field of media technology written for the School of Computer Science and Communication, CSC, at the Royal Institute of Technology, KTH, in Stockholm, Sweden. The thesis was executed during a time period of five months, with the last three weeks in Stockholm, Sweden and the rest of the time in Buenos Aires, Argentina.

I wish to thank professor Ana María Andrada at UCA, Argentina, for helping me in the beginning of this thesis. The professor led me through the basics of e-learning and the concept of learning objects. I also received good textual content, feedback and recommendations from professor Andrada.

I also wish to thank lecturer Stefan Hrastinski and lecturer Daniel Pargman for their help and support in the creation of this report.

I thank my brother Henrik Ek who also has been a great support by helping me out with the more formal language in this report.

Those who submitted answer to the survey are also thanked for their participation.

At last I thank Mathvids.com for letting me use the video of the explanation of Euclid's algorithm in my prototype.

Table of content

1. Introduction

This is where the objective is presented along with how I got the idea, the problem formulation and the project limitations.

1.1. The present

People are today getting comfortable in this era of new media. Web 2.0 including blogs, podcasts, social networks like Facebook, Twitter and Flickr, are technologies for an everyday usage. And its existence is not only on the Web but also in our mobile devices. The Web is also a great information source where it is possible to get information about almost anything. Now, if having were the same as knowing, we would all know what the Internet has got to offer. But it is obvious that having is not equal to knowing.

In a world with these technological possibilities I found myself asking why there is not a better way of learning. It is true that the Web is full of so called tutorials, which basically just guides you through a process of doing one thing. Tutorials are for the most part written text with images and/or video. But e-learning, education on the Web, could be more than what it is today with the everyday technology we are so accustomed to.

I found out about a technology called learning objects (LO). It is a ten years old theory of building digital content objects for educational use, which are supposed to be platform independent and easily transferable between systems. The objects are basically conveying one small specific topic through explanations and exercises. Although the theory is an efficient and widely appreciated one, the practical use of it is far from comprehensible. The one of most popular learning object standard today is called SCORM(2.5).

"Creating a sharable, reusable, interoperable SCORM courseware need a team to collaborate together, such as: instruction designers, multimedia managers, and program developers." - Suxia Xu, Shaozi Li [11]

According to the cite above, it would be difficult for a teacher who would like to create a learning object with this standard for his course, if he is not an extraordinary engineer and designer himself.

1.2. Project objective

In this project the objective is to find a way to implement the ideas of learning objects in a simple way while teaching mathematics. Now, simple is a relative word and thus comes the complexity along with it. But to make it clear I will aim for a standard that can let a teacher create learning objects without a team of engineers and designers. A teacher in any mathematical subject should be able to create this learning object in a way that is helpful and applicable in his course. With simple learning objects the system interpreting the object can also be created simple.

"When two theories are equally defensible on other counts, certainly the simpler of the two is to be preferred on the score of both beauty and convenience. But what is remarkable is that the simpler of the two theories is generally regarded not only as the more desirable but also as the more probable." - Willard Van Orman Quine on simplicity of theories.[12]

1.3. Questions asked in this project

- How can learning objects be made simpler by focusing on teaching and learning mathematical methods?
- How could a simple mathematical learning object be structured?

1.4. Limitations

To find answers to the questions asked above in the amount of time given for this thesis I needed to limit my work. The first limitation is already done, simply by focusing my questions at mathematical learning objects instead of all varieties of subjects. I will also keep my prototype of the learning management system in the scope of a Web based system with the only functionality to present the learning objects created.

2. Background

This part will describe the technical and pedagogic background. The concept of learning objects and learning management systems are also presented.

2.1. Technical background

The technologies in this project are all, except XML, used for presenting the learning objects in the Web based prototype. Note that these technologies are all constantly in a phase of development.

2.1.1. eXtensible Markup Language - XML

XML is designed to transport and store data. It is a simple way of storing data in tags. For example:

```
<name>Niklas</name>
```

If the tags are written in a descriptive way the whole XML is made readable by humans. But the true benefit is its potential of being converted into such a wide range of presentations. This is made possible with the XSLT (see next topic).

2.1.2. eXstensible Style sheet Language Transformation - XSLT

XSLT is a very powerful language for transforming the XML into other languages and presentations. It can transform XML into HTML (see below), a PDF document, a keynote presentation and more.

2.1.3. Web technologies

I base the prototype on the Web technologies PHP, HTML and CSS.

2.1.3.1. Hypertext Markup Language - HTML

HTML is the dominant markup language used for the world wide web. It makes it possible to create static Web pages. The most recent version of the markup language is HTML5 which enhances the ability for video and audio. It also makes it easier to describe navigation and blog posts etc. [8]

2.1.3.2. Cascading Style Sheet - CSS

CSS is in combination with HTML the core technologies for building Web pages. CSS is the language used to describe the presentation of an HTML page, including colors, layout and fonts.[8] It is possible to create extraordinary Web design, along with images, using HTML and CSS.

2.1.3.3. Server-side scripting

The most efficient way to build a multi functional and dynamic Web page is to use a server-side scripting language. In this project the technology chosen is PHP: Hypertext Preprocessor (PHP)[5]. PHP also has a function for processing XML with an XSLT, hence the style sheet transformer is getting the power of being dynamic.

2.2. Learning management system - LMS

LMS is a system which role is to organize and visualize the learning objects, the courses, the learners and the teachers. The LMS does not need to be based on Web technology because the learning objects are written in a platform independent way. It can for example be written as a desktop program or as a mobile application. One LMS can use the same learning objects as a LMS based on another system.

2.3. Learning Object - LO

Further explanations of learning objects.

2.3.1. Definition

Its definition is not clear and it still got various definitions in the community. These are some of the properties in common that gives a general definition of LOs.[10]

- Accessibility: the LO should have the proper metadata so that it can be searched for and referenced.
- Reusability: the LO should function as many times as it is needed. Its content should not refer to other information than the information in the learning object itself.
- Interoperability: the LO should be independent from the way it is presented and should work in multiple learning environments.

2.3.2. In comparison with tutorials

One strength that makes the LOs different from tutorials is its interactive exercises. It has got questions that the learner can work with. When an answer is submitted a feedback will be returned.

The other big strength is that a LO is movable between systems and has the ability to be presented in various ways. A tutorial on the other hand is a static article on a Web page and it cannot be moved from its place in a smooth way.

2.4. Pros and cons with LOs written in XML

XML, as described earlier, is a language for storing data. Its properties fulfills the definition of learning objects and that is why XML is a functional way of describing the objects. Here is a list the pros and cons of LOs when written in XML.

2.4.1. Pros

Here are some of the greatest advantages.

2.4.1.1. Highly reusable

You can use the learning objects over and over again, add or remove content from them. They are created to be small and not dependent of other sources than themselves. This makes it easy to create various courses with the same learning objects.

2.4.1.2. Platform independent

XSLT tools can be utilized to present the LO for various uses. This means that the LO also is independent from the presentation as well. All the data can for example be put from the learning object on to a Web page. It can also be chosen to create a menu of the titles and the solutions can be hidden or code protected. It is also possible to print for example all the explanations on to a PDF or even transform various learning objects to a keynote presentation.

2.4.1.3. Continue the development

XML makes it very easy to add new features to the learning objects as the technological part advances. It does not need to be rewritten, adding new tags to it will not change any of the other information.

2.4.1.4. Quality - Collaboration

The same learning objects are to be used over and over again not only by the same institute or university but by various. This makes it easy to collaborate on the learning objects to make the exercises richer and of higher quality. All the professors in discrete math can look at the learning object of Euclid's algorithm and correct errors, add exercises etc.

2.4.1.5. Possibilities of a learning management system (LMS)

Learning objects constructed in XML makes it easy to find and present exactly what you want, in any way you want. The LMS is the system that defines the way to present a learning object. The LMS can have a register of the students and teachers with all the information of importance. Every student can also have a register of the learning object exercises completed or other kind of information connected to the learning objects.

Examples:

- Make a test/exam by collecting only the question from various learning objects that match a specific course.
- Export the solutions from a learning object of choice to a PDF document or keynote presentation (keynotes are written in XML, so it is an easy transformation)
- Add extra tools while presenting the learning object on a Web page, like an extra text field for the learners own calculations.

2.4.2. Cons

These are the negative parts of LOs.

2.4.2.1. Integration

The structure and self dependence of the learning objects are great features for keeping it clean and logic. But it also makes it more difficult to create exercises that include more than the area of the learning object. This is why the learning process should not be depending only on the learning objects, but more as a tool for teaching special techniques. As this can become a complex part I leave it outside the scope of this thesis.

2.4.2.2. The social learner

The learning objects do not support discussion between learners. The solution would be to integrate a forum in the LMS.

2.5. Sharable Content Object Reference Model – SCORM

SCORM is a set of technical standards that governs how online learning content and LMSs communicate with each other.[6] SCORM is a great reference model for sharable content objects, as its name implies. It can be a solution to mathematical learning objects because it is a standard on how to write objects in a way that can be readable by SCORM based LMSs. But it got a complexity to its functionality that can be made simpler when creating mathematical LOs. The LO created with SCORM is based on three sub concepts[7].

- The Content Packaging section specifies how content should be packaged and described. It is based primarily on XML.
- The Run-Time section specifies how content should be launched and how it communicates with the LMS. It is based primarily on ECMAScript (JavaScript).
- The Sequencing section specifies how the learner can navigate between parts of the course (SCOs). It is defined by a set of rules and attributes written in XML.

SCORM is produced by Advanced distributed learning (ADL), a research group sponsored by the United States Department of Defense (DoD)[1]

"The specific goals were to: […] Establish guidelines on the use of standards and provide a mechanism to assist DoD and other Federal agencies in the large-scale development, implementation, and assessment of interoperable and reusable learning systems."[7]

SCORM was not created to present mathematical methods and processes specifically. Making it possible to add all types of content in all types of ways makes it complex.

2.6. Pedagogic background

The core purpose of the learning objects is their pedagogical functionality. Better said, the learning objects are made to give the learner new knowledge. That is why it is important to observe the structure from the pedagogical point of view.

2.6.1. The polygon

The theory of viewing the knowledge as a polygon is based on that the subject sought has several view points or edges. From a different edge you see the subject from another angle. When knowing how the method works from all angles, the method is mastered by the learner. There can be an infinite or a finite amount of edges, depending on the complexity of the subject. If the subject chosen is Euclid's algorithm then the first edge could be to solve the problem with two integers higher than one, this is the common way. The second edge could be to use negative start values, what would happen then? The amount of edges depend on the mathematical method. But they are important to reveal and use when creating explanations and exercises. It is a way of structuring the content. Conveying the edges of the polygon of a subject would give the learner a wider spectra of the method taught. This theory was introduced to me by professor Ana María Andrada, who is researching e-learning at UCA, in Buenos Aires.

2.6.2. Learning styles

To better convey the content in a pedagogical way the understanding of different learning styles is important.

"Research shows us that each learning style uses different parts of the brain. By involving more of the brain during learning, we remember more of what we learn."[3]

Implementing this into this project means using different media formats to express the content which is to be taught. Much of the implementation of this theory is based on the content which the author will create for the LO. But the important part is that the structure supports these various formats of content, e.g. video, animation, audio and more.

3. Method

To answer the questions asked in this project I chose to create a prototype and after that make a survey for feedback. The last step was to evaluate the prototype and discuss the feedback. I first present the chosen methods and after that how it was done.

3.1. Research and interviews

To find the information needed to build the prototype I will read papers, articles and books. Another source of conceptual information will be interviews and discussions with Ana María Andrada, a university professor in the field of e-learning at UCA, Argentina.

3.2. Development

"How can learning objects be made simpler by focusing on teaching and learning mathematical methods?", is the main question in this project. To make something simpler it is needed to know what is more complex. I am comparing with SCORM(2.5) which is one of the most accepted open standards in the industry today. By focusing on using the learning objects for the only purpose of teaching and learning mathematics I believe that I can make a standard for mathematical learning objects in a simpler way than for all subjects. I will create a prototype in XML because of the advantages already described(2.4.1). This will give me the answer whether it was possible or not. If I am able to create a simple mathematical learning object during the scope of this thesis I can demonstrate that it was an easy task.

The LO prototype will then be tested in a LMS because the LO itself does not prove its functionality. I will create a prototype for the LMS as well. But what I am really going to create is a tool for presenting LOs in a Web browser. I will call it a LMS even though it will not take in consideration who is using it. The LMS will not save information about learner, teachers and courses. Its purpose is only to present the mathematical LO in a way it would be presented in a real learning management system.

When I developed a LMS for my only LO it might function great with that single LO, but not with other LOs. That is why I will have to create several LOs. In order to do so I will extract a template from the first LO and use it when building more.

3.3. Feedback and opinion

If I did not ask for the opinion of others then my development would be difficult to evaluate. I am going to get the feedback needed to support or dismiss my theories and prototype using a questionnaire. The survey should be answered by students and teachers that are familiar with learning and teaching mathematics. I will also ask further questions to get more feedback about the simplicity of the XML. This will be made by asking those students and teachers who possess basic knowledge of XML what they think of the code presented in the pure XML file.

3.4. Evaluation and conclusion

When the prototypes are developed and I have received feedback from students and teachers I can start evaluating my work. I will question my project and come to a conclusion whether I answered the questions or not and whether I found a good solution or not. A view of future development will be discussed.

3.5. The prototypes and the survey

The prototypes are here presented after its development. I also write about the survey.

3.5.1. The LO for Euclid's algorithm

The design of the first learning object was devoted the most time, it was the core problem to solve. The four parts of the LO design are described. For the full XML, see Appendix A(8. Appendix A).

Opening the learning object in XML I only needed the learning object tag:

```
<learningobject>
      (This is where I put all parts of the LO)
</learningobject>
```

3.5.1.1. Meta data

The definition of learning objects clearly define that meta data is a key part of the structure. It is important to describe the object to make it searchable and identifiable in a larger system.

The meta data can be expanded to more than the basic required fields. But the fields that I chose to define as required are:

- Title – The LO requires a title name.
- Description – For describing the content e. g. in a search engine.
- Tag(s) – The LO is searchable through its tags, keywords.
- Author – The creator of the LO needs to be specified. Can be more than one.

Other tags can be added and used, but these are the ones required to fulfill the basic requirement of a LO.

The XML representing this part will look like this:

```
<meta>
      <title></title>
      <tags></tags>
      <description></description>
      <author></author>
</meta>
```

3.5.1.2. Introduction

Before a learner can get an explanation on how a mathematical method works, the learner need to know what the method is. The introduction can include text, images, photos, videos, animations and audio. Its purpose is to convey what the mathematical method will help the learner to solve. In this case what Euclid's algorithm does. The introduction do not explain how it is done, only what it does.

In code it looks like this:

```
<introduction></introduction>
```

3.5.1.3. Explanations

After knowing what the mathematical method does the learner need to know how it is used to solve a problem. The explanation should explain step by step how the calculation is done. If the calculation in a method would change depending on the start values then these variations of calculations should be explained in a new explanation. This means that the LO will have more than one explanation depending on the amount of ways the calculation can shift with different start values. The explanations can, as the introduction, use the same variety of media formats to convey its content.

The teacher creating content can also present the same type of calculation but through another media. For example, explaining the Euclid's algorithm in video format. This helps to give a broader understanding for different people and learning styles(2.6.2).

It is also helpful if there are explanations both with numbers and in an abstract way when applicable.

```
<explanation type="">
      <question></question>
      <step>
            <title></title>
            <content></content>
      </step>
      ...(more steps)
</explanation>
...(more explanations)
```

3.5.1.4. Exercises

The last pieces of the mathematical LO are the exercises. This gives the learner the possibility to try his new knowing and convert it into knowledge. What I claimed about the variety of learning styles should also be applied to the exercises. This means that the exercises should not only be different because there are different start values but they should also be presented through various medias. The exercises can also be used as examples when they got a solution explaining every step of the process.

"Repetitio est mater studiorum" (Repetition is the mother of learning) – Latin cite

The exercises in XML looks like this:

```
<exercise>
      <question></question>
      <answer></answer>
      <solution></solution>
</exercise>
...(more exercises)
```

3.5.1.5. Content

For the LO to be a good tool for learning, the content needs to be great. The LO and its structure are in reality only the medium for transportation of the content. Its function is more of a help in organizing and distributing the subject. In this case the content is specified to the field of mathematics. To write content in a good way the

teacher needs to have great knowledge of the topic and of course know how to describe it via the learning object. I created the content for the first LO and chose to write about Euclid's algorithm. It is a mathematical method which is not too complicated and one I recently learned myself. For the full XML with content, Appendix A[8. Appendix A].

3.5.2. LMS

To see if my learning object worked in practice I also created a LMS. This is why I took the time to learn how the technologies[2.1] work. The technologies required certainly exist, therefore the only thing I had to do was to build the LMS from scratch. This demonstrated that the learning object I made really worked in a system. See the LMS in the next chapter[4.1.2].

3.5.3. More LOs

I created a few more LOs because I needed to see that the LMS not only shows my first LO as it should but any LO imported. With the structure from the first LO this task was not more complicated than filling a form with mathematical content.

3.5.4. Survey

After the prototypes were constructed I made a survey to find out what teachers and students thought of the idea and the concept behind learning objects. I specifically asked those with knowledge of XML to express their opinion on the learning object code. The survey was sent out ones via email to students of media technology at KTH and computer science students at UCA. Several teachers from both universities in mathematics and programming were also asked to answer the same survey.

In the introductory part of the survey I explained the concept of learning objects and led the person to my prototype of the LMS where the person was asked to click the learning object Euclid's algorithm. It was not automatically presented from the beginning in purpose to give the person a feeling of choosing the object on his/her own. The Introduction then appeared in the content field and a navigation bar to the right. The navigation includes links to the explanations and the exercises included in the LO. I asked the person to explore the functionality. After reaching a sense on how the system works with the LO the person is asked a few questions.

See Appendix C for the full survey and all of its questions explained.[10. Appendix C]

4. Result

These are the result of the development and the survey.

4.1. Prototypes

Here I describe how the development went.

4.1.1. The LO

The prototype was built rather quickly. The XML was not difficult to design after the theoretical design was made. The part that took the most time was writing the mathematical content.

See the XML, Appendix A(8. Appendix A)

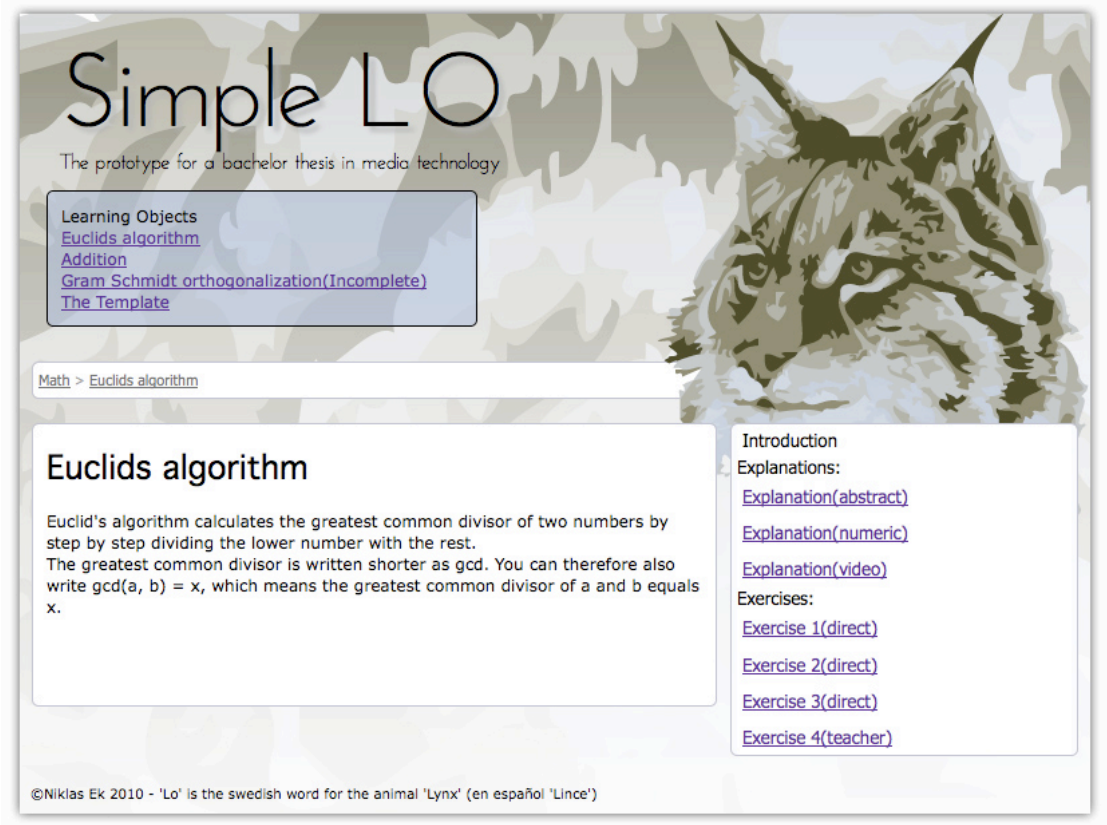
4.1.2. The LMS

The LMS presented the LO with the chosen content in a centered area with a navigation bar on the right hand side. The navigation for the explanations and exercises of the object is created dynamically by the LMS. It searches through the LO and puts a link to the introduction, each explanation and each exercise. Above the content area was the menu for the learning objects. This list came from the PHP script that searched through the folder with all the LOs and listed them.

I created a design and a brand like concept to enhance the user experience. As a logo I chose to use the animal lynx because the word “lo” in Swedish means “lynx” in English. I used a font named “Josefin Sans Std Light” for the topic. This font is gotten from the Google Font API.[2]

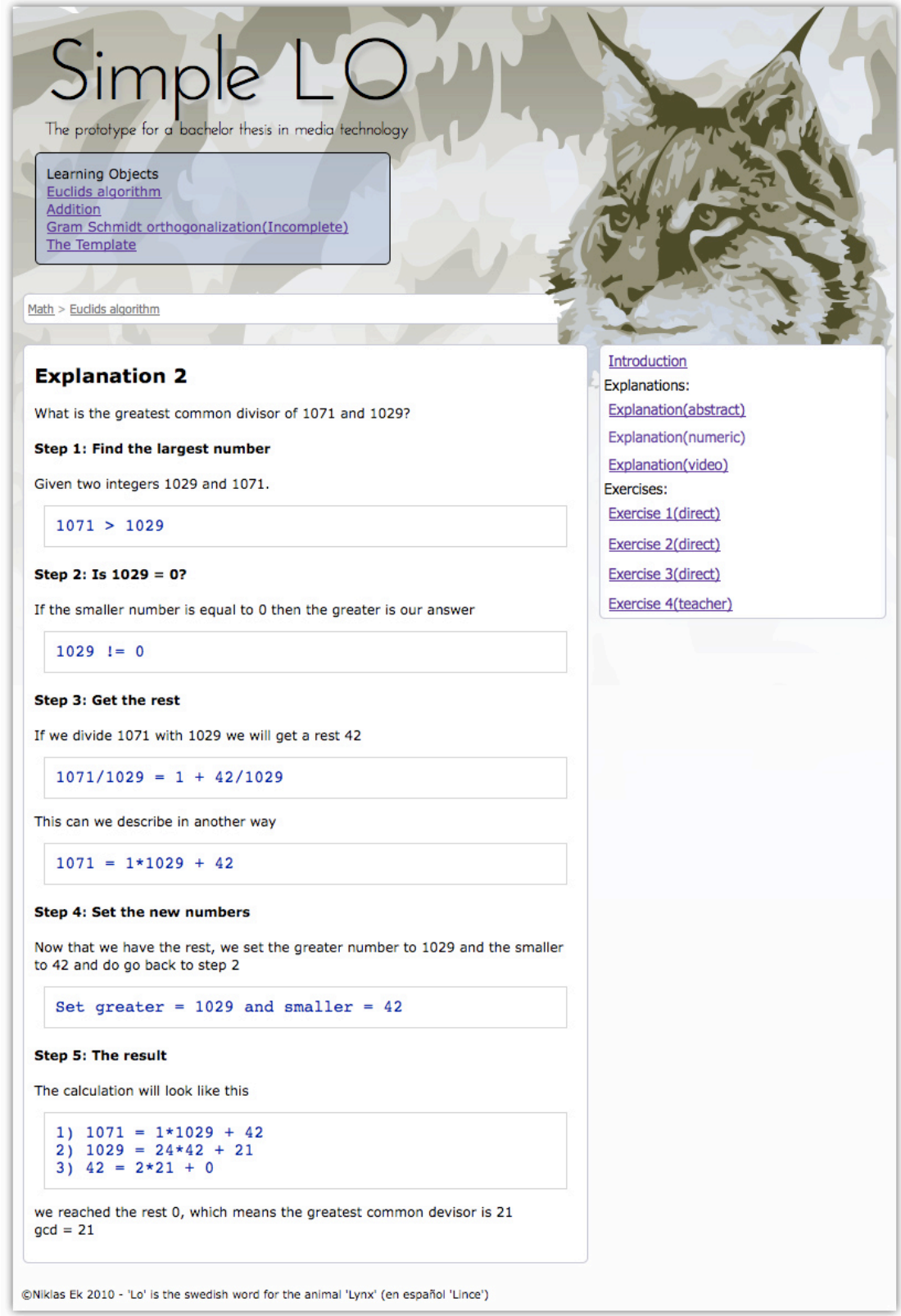
4.1.2.1. The Introduction

This shows the introduction to Euclid's algorithm and the navigation bar to the right.



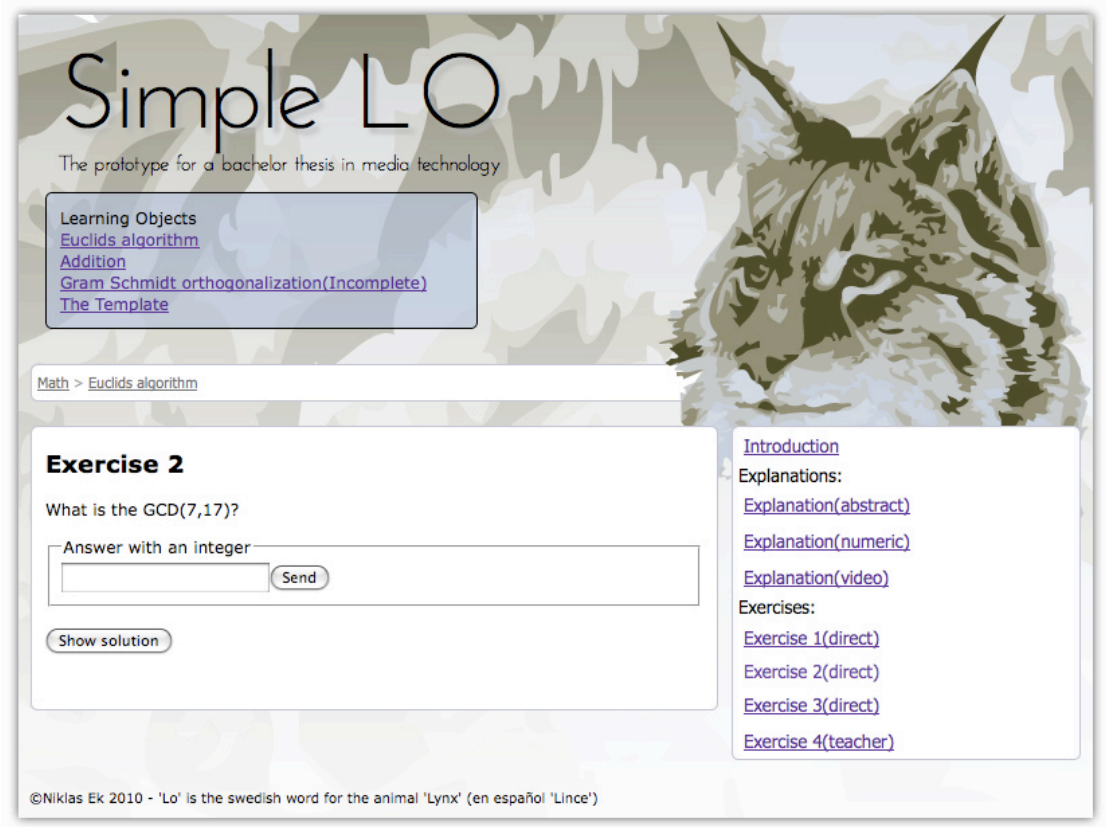
4.1.2.2. An explanation

An example of an explanation, this one is the numeric.



4.1.2.3. An exercise

This exercise is a normal question, here with an integer as the answer. It is interactive and the user can therefore type in the a number and click "send" to receive the feedback. In this prototype I also added the "Show solutions"-button. This was only to show the users that it actually exist a solution to every exercise.

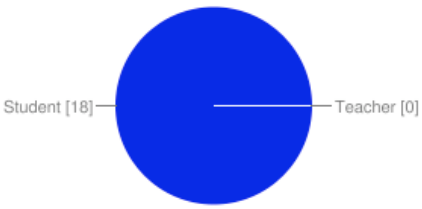


See more of the LMS in Appendix B[9. Appendix B] and on the live Web page[4].

4.2. Survey

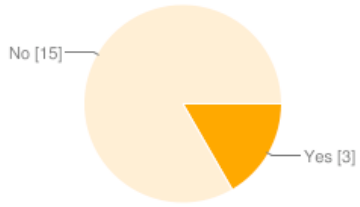
The survey was sent to approximately 80 students and teachers. The participation was 18 persons. Here are the results.

1. **You are a…?**



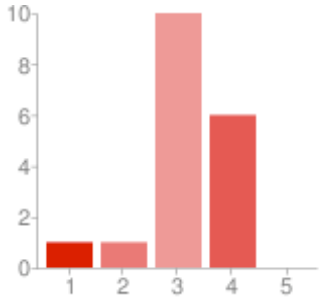
[fig. 5.1]

2. **Did you know about Learning Objects before this presentation[10.1]?**



[fig. 5.2]

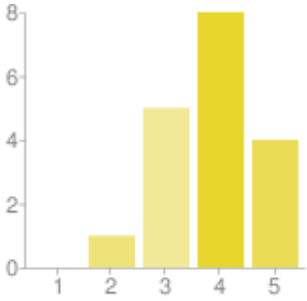
3. **How much do you think a course can depend on this type of teaching/learning?**



[fig. 5.3]

(Not at all) (A whole course)

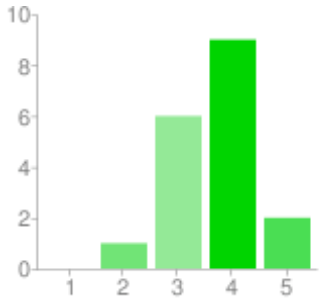
4. **What is your opinion on the Introduction/Explanation/Exercise structure?**



[fig. 5.4]

(Bad) (Really good)

5. **How was the experience from an educational point of view?**



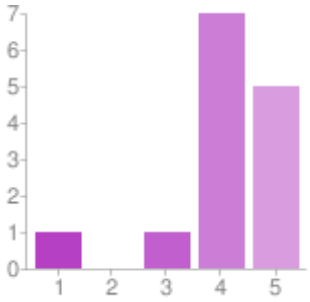
[fig. 5.5]

(Bad) (Really good)

6. **If you wish to motivate the answers above, please write it here.**

I will not present all of the comments I received, but a discussion about these answers is located in the next chapter. [5.3.2.3]

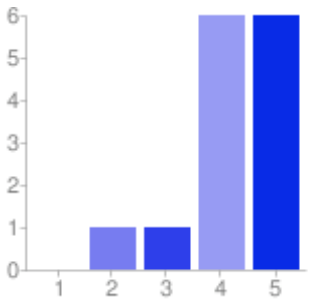
7. **Do you find the TAGS easy to understand?**



[fig. 5.6]

(Not at all) (Really easy)

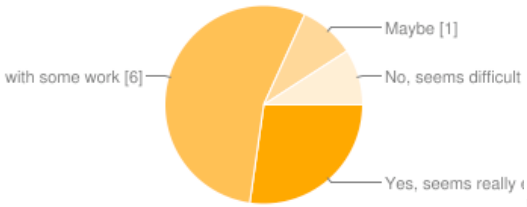
8. **Do you find the STRUCTURE easy to understand?**



[fig. 5.7]

(Not at all) (Really easy)

9. **Do you think you could create your own Learning Object in this manner?**



[fig. 5.8]

10. **If you have other suggestions please share:**

    I will not present all of the comments I received, but a discussion about these answers is located in the next chapter. (5.3.2.3)

11. **Do you wish to see the report when it's done?**

    Not important for the thesis.

5. Discussion

Discussing the result

5.1. About the LO

What I wished to succeed was finding a technical standard for learning objects easier than SCROM, focusing on mathematics. This has nothing to do with the design of the interface, but merely the content package that is presented in the interface. The LO created was designed as I had planned and there were no barriers in creating the LO in XML.

5.1.1. What functionality did I loose making a simple LO?

To create the LO in a simpler way I had to leave out some functionality that SCORM is using. SCORM is built with the capacity of allowing any structure of the LO. The choice is made by the author. But the author also have to explain how this structure works and how the learner is supposed to navigate through the content. In my design I use a strict but simple structure which has one introduction, many explanations and many exercises. I do not leave that opportunity to structure the LO in any other way. By concentrating the LO to a fixed structure there is no need for navigation explanation.

5.2. About the LMS

If a non professional software developer such as myself can succeed with building a LMS, it implies that not only the LO is easily presented in a Web browser, but also that the LMS does not need to be created in a complex way. In fact, it is much less complicated and less functional than the most known social networks.

5.3. About the survey

The discussion of the survey as a whole, the low participation and the questions answered.

I am pleased with the survey, even though the participation was low, because I know that I, with this survey, only received fast answers based on the prototype. The persons asked was not accustomed to use the system in their own learning and they

did not get the chance to try out a real LMS with its advantages. This was out of the scope of this thesis. But I believe that the survey I made was an approach that helps to see tendencies of what people would think of a real system. This system should of course be tested in a real class situation for a better evaluation.

5.3.1. Participation

What surprised me was how few actually answered the survey. The reasons for this might be one or several of the following.

- Because it was sent out via e-mail, it was looked at and dismissed or forgotten.
- The person did not have a browser other than IE, which could not represent the LMS correctly.
- It took too much energy and/or time reading through the instructions or exploring the LMS.
- The survey was sent out during the high season for vacation in the academic world.

The survey had to explain the basics of what my prototype did to get valuable and thought through opinions. I can only guess that this also is one of the reasons for the low participation. None of the teachers that I sent the survey to answered it. Therefore I did not get valuable information on how a professional would think of the prototype as a tool for teaching. Neither did I get a teachers opinion on the XML. I do not know why none of the teachers did not answer, I can only speculate.

5.3.2. Questions

The 18 persons that did answer the survey did give good information.

As mentioned above, out of the ones who answered the survey, a 100% were students. Out of them 17% had heard about LOs before. This mean that not many of the students had heard about a technology that has been existing for 10 years.

5.3.2.1. The LO based course

If whole courses could be dependent on this kind of learning we would not be needing teachers in mathematics. But non of the students asked agreed on that. More than half of the asked(56%) put down a three on the scale from one to five. One third put down a four. The other twelve percent was below three. This means that the most people asked believed that it was a useful tool in teaching math, but not at all for teaching whole courses.

5.3.2.2. The structure and the experience

The structure was well accepted among the students. The average was 3,8 in how good it was, on a scale from one to five. The experience had similar numbers and I believe that the over all experience rated was what could be expected. To see a Web page with this kind of information might not be what they are used to but it is neither something odd. There was text, a video, links in a navigation bar and form elements to submit answers to questions. These are all elements which they are used to from other Web pages. This is only the interface and as mentioned earlier the LOs has nothing to do with its way of being presented.

5.3.2.3. Textual opinions

I got several great opinions for further development of the system. These are some of them.

"As seen in Euclid's algorithm Lesson (*sic*), for me it is very important to provide the student with several methods of understanding, such as abstract, numeric and video. Some students may find useful one method, and other students one different." The person is pointing out the learning style theory, this helps because it shows that it is not only a theory but a common belief.

"Make sure to give people feel-good-feedback. A great rewarding system for answering correct is a key to success!". This is something great to add to the pedagogical part of the LMS. A reward system might give a higher motivation to solve by learning. But it shall not be implemented in the LO standard because it is just a feature of the LMS and the visual presentation.

"I'd like to be able to lock the exercise so you have to try to solve them before being given the answer. A maximum of 5 wrong answers then being given the solution." Several persons wrote that they did not feel motivated to get the answer by solving the calculations because the answer was easily obtained by clicking the solution button. This is understandable and the reason why I put the button along with the question was because I wanted to show that the exercise in fact did have a solution. In a real version of the LMS the solution should not be that easily obtained. The LMS has to take care of this if applied because this should not be embedded in the LO.

One other textual opinion from a person was too use this tool mainly for repetition before an examination. This might be a good way to use this system, but I believe that it should be part of the whole course. It should be used to get up to date with the course and the methods explained over time. By viewing the methods not only in class but also in the LMS the learner will have more of a variation in his/her learning process.

6. Conclusions

For a final look back on the project and the future of its work.

6.1. The simple mathematical learning object – SMLO

The first conclusion I am going to make is that I have created a rather small but a real standard for simple mathematical learning objects. It was possible to create a LO simpler than SCORM and make it work in a Web browser via a LMS prototype. From the prototype I can state that this way of writing pedagogical content is working, it follows the definitions and upon that it is simple. I can state that the objects are simple because, not only did I create both the object standard and the SMLO prototype, but the majority of those who answered on the XML questions thought they could create these objects themselves too.

6.2. Expanding SMLO

I believe that the future challenge of SMLO, if used as a standard, is to keep it simple and develop it in a slow pace. The more it develops the more complicated it will become. Now, this might not be a bad thing even though I was avoiding just that. If the SMLO would become relatively advanced, and therefore (A)MLO, then the focus would still be on teaching and learning mathematics. That is an important statement because if it does not focus on mathematics it is open to all subjects and might need to be as complex as SCORM to match the requirements.

6.2.1. Pedagogical enhancements

Because I knew that the ones who tried the prototype was not going to deeply understand a pedagogical pattern I did not take the time to implement the pedagogical ideas that I researched in the prototype. With an extra attribute on the explications and the exercises it can become possible to put an edge number on them. This would make it easier to implement the pedagogical idea of the polygon[2.6.1]. This could also make it possible to select only the explanation and exercises with a chosen edge for specific training in a personalized system. But for the most part it is up to the author to implement pedagogical theories in the content, for example a variation of media, to stimulate the variation of learning styles.

6.3. Further development on LMS for SMLO

Even though the ones that had knowledge of XML thought that it was relatively easy to construct a SMLO by coding from scratch I want everyone to be able to create SMLOs. In a similar way that I created the LMS to present the LOs it can also be constructed as a system that generates and edits LOs. This would help the teachers that are not familiar with XML to add to or create new LOs for his own course or the community of mathematics.

6.4. The questions asked

- How can learning objects be made simpler by focusing on teaching and learning mathematical methods?
- How could a simple mathematical learning object be structured?

These were the main questions of this thesis. As I wrote in discussion(5.1.1), I could make the learning objects simpler by removing the open structure that SCORM uses. By creating a static structure the object loses much of SCORMs complexity which is needed to explain how the content is read. I am also leaving more to the LMS when I structure all the content in this manner. The LMS has to read through the XML to find the explanations and exercises, both for the creation of the navigation bar and also for the presentation. A SCORM object can have a self dependent system like a flash which takes care of all this.

The SMLOs is also meant to be used only in itself and not as a part of another learning object as you can use a SCORM based object. This type of reusability is nothing I wished to embed in the structure and by not doing so I add to the simplicity. To answer the second question, one way the SMLOs can be structured is by focusing on just the explanations and the exercises as parts of one single method and therefore one single LO. See a full example of the XML structure in appendix A. When the content do not accept other information than explanations and exercises the structure becomes much simpler.

In conclusion I dropped much of the SCORM LOs flexibility when making the new LOs specifically for mathematical methods and it was because of this I could make them easier both to create and to use. The SMLO is not yet a full standard. But with continued researching of the SMLOs usability in real world learning they could become a valuable tool for future teachers and students in mathematical subjects.

7. References - Literature

Here is the complete list of references divided into groups.

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Appears in: Synthese Volume 15, Number 1.

8. Appendix A – Prototype LO

```
<?xml version="1.0" encoding="UTF-8"?>

<learningobject>
    <meta>
        <title>Euclid's algorithm</title>
        <tags>Euclid, algorithm, greatest common divisor,
        gcd, greatest common factor, gcf, integers</tags>
        <description>How to calculate the greates common devisor
        of two integers with Euclids algorithm</description>
        <author>Niklas Ek</author>
    </meta>

    <introduction>
        Euclid's algorithm calculates the greatest common
        divisor of two numbers by step by step dividing the
        lower number with the rest.<br />The greatest common
        divisor is written shorter as gcd. You can therefore also
        write gcd(a, b) = x, which means the greatest
         common divisor of a and b equals x.
    </introduction>

    <explanation id="expabs" type="abstract">
        <question>What is the greatest common divisor of <v>a</v>
        and <v>b</v></question>
        <step>
            <title>Find the largest number</title>
            <content>
                <text>Given two integers <v>a</v> greater
                 than <v>b</v>.</text>
                <math>a > b</math>
            </content>
        </step>
        <step>
            <title>Is <v>b</v> = 0?</title>
            <content>
                <text>If <v>b</v> is equal to 0 then
                <v>a</v> is our answer.</text>
                <math>b=0  =>  gcd(a,b)=a</math>
                <text>But if not, then we continue to the next step.</text>
            </content>
        </step>
        <step>
            <title>Get the rest <v>r</v></title>
            <content>
                <text>If we divide <v>a</v> with <v>b</v>
                we will get a rest <v>r</v></text>
                <math> a/b = q + r/b (q is an integer > 0) </math>
                <text>This can we describe in another way</text>
                <math>a = q*b + r</math>
            </content>
        </step>
```

[fig. A1] This is the first part of the SMLO for Euclid's Algorithm. Note that the code part on the next page do not continue where this one ends.

```
    <explanation id="expvid" type="video">
        <question>A video presentation of
        Euclid's Algorithm from Mathvids.com</question>
        <video>
        <source type="ogg" codec="''">los/video/euclidsalgorithm.ogv</source>
        <source type="mp4" codec="''">los/video/euclidsalgorithm.mp4</source>
        </video>
            <title>See the video</title>
            <content>
                <text>This video demonstrates Euclid's Algorithm in a sligthy
                different way.</text><text>The video is a short piece of the
                full video found on &lt;a href="http://www.mathvids.com/
                lesson/mathhelp/628-lecture-18-euclids-algorithm"&gt;
                Mathvids.com Euclid's Algorithm.&lt;/a&gt;All rights are
                theirs according to creative commons, find more info on
                their page.</text>
            </content>
    </explanation>

    <exercise id="3"  correction="direct">
        <question>What is the greatest common divisor of 1071
        and 1029?</question>
        <answer type="int">21</answer>
        <solution>
            <text>The solution is:</text>
            <math>1) 1071 = 1*1029 + 42<br />
                2) 1029 = 24*42 + 21<br />
                3) 42 = 2*21 + 0<br /></math>
            <text>We reached the rest 0, which means the
            greatest common devisor is 21</text>
        </solution>
    </exercise>
    <exercise id="4" correction="direct">
        <question>What is the GCD(7,17)?</question>
        <answer type="int">1</answer>
        <solution>
            <text>The solution is:</text>
            <math>1) 17 = 2*7 + 3<br />
                2) 7 = 2*3 + 1<br />
                3) 3 = 3*1 + 0<br />
                we reached the rest 0, which means the
                greatest common divisor is 1</math>
        </solution>
    </exercise
    <exercise id="5" correction="direct">
        <question>Is the GCD of 17 and 7 equal to 1?</question>
        <answer type="bool">true</answer>
        <solution>
            <text>The solution is:</text>
            <math>1) 17 = 2*7 + 3<br />
                2) 7 = 2*3 + 1<br />
                3) 3 = 3*1 + 0<br />
                we reached the rest 0, which means the
                greatest common divisor is 1</math>
            <text>So the answer is Yes.</text>
        </solution>
    </exercise>
    <exercise id="6" correction="teacher">
        <question>What does it mean that the GCD of two
        numbers is 1?</question>
        <answer type="text">This means that they are
        prim number to one and other etc...</answer>
    </exercise>
</learningobject>
```

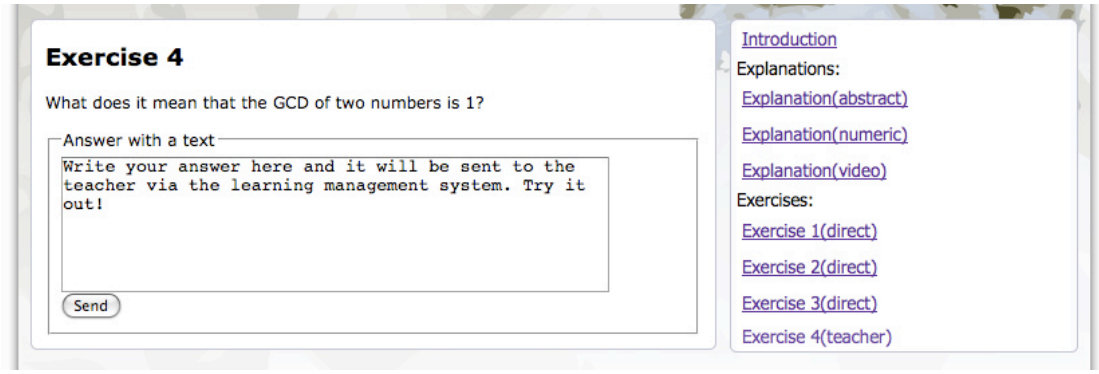
[fig. A2] This is the last part of the SMLO for Euclid's algorithm.

9. Appendix B – Prototype LMS

See the live version of the LMS at the Web page[4]

[fig. B1] The LMS looks like this when no LO is loaded. For the purpose of the survey the LMS suggests the user to choose Euclid's algorithm.

[fig. B2] Here the video explanation is loaded.



[fig. B3] This exercise is meant to be answered with text. This is why it does not have a solution and the answer submitted will be sent to a teacher who corrects the answer and sends back a feedback.

10. Appendix C – Survey

10.1. The presentation

This is the text I wrote in the survey as a presentation of my thesis.

> *This is a scientific questionnaire for a bachelor thesis in Media Technology.*
>
> *The survey is meant to be answered by teachers and students that are familiar with teaching and learning mathematics.*
>
> *The questions are to be answered after trying my prototype(link below) of a web based learning system. The system will have several "learning objects" available, but try the one named Euclid's Algorithm and try to explore the functionality as much as you can. (If you have the possibility; use an Internet browser OTHER THAN Internet Explorer.)*
>
> *Teach me Euclid's Algorithm -> http://www.niklasek.se/lo/lms.php*
> *Approximate time: 5-15 min*
>
> *After testing the LMS(Learning Management System) above, please fill the survey with your own thoughts and experiences. You can answer in Swedish or Spanish if you wish.*
>
> *Niklas Ek*

Before the part with XML questions I also added this information:

> *If you are not familiar with XML you can jump down to the last part. If you are, please look through the real learning object and answer the following questions.*
>
> *LO of Euclid's Algorithm: www.niklasek.se/lo/los/euclidsalgorithm.xml*
>
> *If the browser don't show the xml in a good way, look at this instead: www.niklasek.se/survey/loxml.gif*

10.2. Questions

These are the questions for the survey and a explanation to why they were used.

1. **You are a…?**
   Options: Student or Teacher.
   It is important to know from what side of education the person is coming.
2. **Did you know about Learning Objects before this presentation?**
   Options: Yes or No
   If a person has more knowledge about LOs than that persons opinion is probably more thought through.
3. **How much do you think a course can depend on this type of teaching/learning?**
   Scale: 1(not at all) to 5(a whole course)
   This was to see if the person felt that this method of learning was a good way of teaching a course, and if not, then how much.
4. **What is your opinion on the Introduction/Explanation/Exercise structure?**
   Scale: 1(bad) to 5(really good)
   I created the structure from my own experience and logic. Here I question if it was a good idea or not.
5. **How was the experience from an educational point of view?**
   Scale: 1(bad) to 5(really good)
   The experience is mostly a part of the LMS. This means that if I did a good job designing the LMS the experience should be good too.
6. **If you wish to motivate the answers above, please write it here.**
   A text field.
   If anyone wish to point out his or her opinion in words then this gives that opportunity.
7. **Do you find the TAGS easy to understand?**
   Scale: 1(not at all) to 5(really easy)
   The question was right after the presentation of the XML file. This question is optional and aimed to those with knowledge of XML.
8. **Do you find the STRUCTURE easy to understand?**
   Scale: 1(not at all) to 5(really easy)
   Same as 7.
9. **Do you think you could create your own Learning Object in this manner?**
   Four options: “Yes, seems really easy”, “Yes, with some work”, “Maybe” and “No, seems difficult”
   I wished I could make others try to create learning objects for real, but that

was outside of the scope of the thesis. This question had to compensate for that.

10. **If you have other suggestions please share:**
    A text field.
    This was the place where the person answering could leave a suggestion to enhance the LO and/or the LMS.
11. **Do you wish to see the report when it's done?**
    A text field.
    If the person, who put down a few minutes to help me, would like to see the end result this is where he or she would fill their e-mail address.