Institutionen för datavetenskap
Department of Computer and Information Science

Final thesis

Developing a Source Criticism Learning Activity for a Digital Learning Environment in History

by

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LIU-IDA/LITH-EX-A--15/016--SE

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Abstract

Source criticism is an important part of the national curriculum in the history subject in middle grade schools. This master thesis presents the development of a digital learning activity for teaching students about source criticism concepts. The learning activity was developed by first researching the history curriculum and how source criticism is taught within the subject. A conceptual design was drafted based on these findings and the design of an existing framework for teaching students within the history subject. The existing framework, and the developed learning activity, is based on learning-by-teaching implemented in the form of a teachable agent. The teachable agent act as a tutee that students have to teach themselves, increasing students’ motivation and learning. By teaching the agent, students improve their own learning. The final implementation of the activity is integrated into both the technical framework and the narrative of the existing environment.
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Chapter 1

Introduction

This thesis examines how to develop a digital learning activity with focus on teaching source criticism within the history subject in middle school, with the help of a pedagogical concept called *Teachable Agents*. The work was carried out as a project together with the Educational Technology Group at Lund University and Linköping University.

1.1 Background

Educational Technology Group at Lund University and Linköping University (Educational Technology Group 2015) is developing a digital learning environment for the history subject in middle school. The two main goals are to build a research tool for studying learning processes and to study how to best design digital pedagogical tools for practical use in schools. The learning environment is based on the concept of a teachable agent (TA), a computer agent that is taught by the student. By assuming a teaching role the students own learning is improved. Previous TA-based systems have mainly targeted the STEM (Science, Technology, Engineering, and Mathematics) area, and this educational tool is one of the first to use a Teachable Agent in a humanities or social sciences subject.

The system aims to meet the goals of the national curriculum in history for Swedish middle grade schools. The current learning environment, however, only cover some of the educational goals in history in the national curriculum. Most notably, there is no learning activities to support students learning source criticism and critical thinking in a historical context, an important part of the curriculum.

The national curriculum on history in middle grade school explicitly state that students should learn to critically review, interpret, and value historical sources for using them to create historical knowledge. The student should be able to use historical sources to draw simple conclusions, and describe in a well-developed manner how and why a certain source can be of use.
1.2 Purpose

The purpose of this thesis is to examine how source criticism is taught within the scope of the history subject, and in what way digital learning environments can be used to help this process.

The question is answered by designing and implementing a learning activity, within the existing learning environment framework, with focus on learning goals of the history curriculum regarding source criticism and critical thinking in history for children aged 11-13 (grade 4 to 6) in Swedish schools. This work should result in a proof-of-concept application. This includes a conceptual design that could be used as a basis for further development, a first version in an iterative development process.

The learning activity should support the student in acquiring skills in analysing historical sources, based on common principles for working with historical sources, and illustrate the potential of digital learning environments. Part of this is identifying what properties are used for evaluating historical sources and artefacts, and examine if this is transferable to a digital learning environment.

1.3 Intended Audience

This thesis is intended for an audience with some familiarity of software development in general and web development in particular. Some degree of knowledge of terminology such as JavaScript, Python, and HTML5 should be expected. Anyone not familiar with software development should still be able to understand the main concepts of the thesis.

No prior knowledge or understanding of history didactics or source criticism is required.

1.4 Scope and Limitations

The following limitations apply to the scope of the thesis. The purpose of this work is not to develop a complete tool ready to be used in education, but to be used as background for evaluation and further development of such a tool. Thus, a number of limitations apply:

- Conceptual design is limited to one example and does not cover evaluation of several designs.

- Graphical design is not part of this thesis. Graphical design elements and layout will be separately developed and imported. Alternatively mock-up elements or place holders may be used.

- The selection of historical literature and artefacts that will be used in the learning activity is limited to what is considered relevant for
evaluation and test of this work. The purpose is not to cover all content in the history curriculum.

- The knowledge representation that is used in implementation of the learning activity and teachable agent will be somewhat simplified. This is an interesting area but not the focus of this work.

- The implemented solution will be integrated in an existing framework. This will limit design options and may put some constraints on both design and implementation. A well-adapted integration has priority over best possible design pattern.

- Improvements on the existing framework might be suggested as a result of this work, but the purpose is not to implement framework improvements.

- Testing will be limited to simple software tests. No class-room evaluation or effect evaluation is included.

1.5 Approach

To gain required knowledge in the fields of history didactics and the use of pedagogical agents in digital learnings environments the work was initiated with a literature review of said topics. The purpose of this review was to gain insights necessary to design and build a learning activity based on a solid pedagogical foundation. The history curriculum provided a basis for understanding what middle grade students learn in school. A review of source criticism within a historical context was used to understand how to analyse and value source material. There is a lack of information on teaching source criticism at low and middle grade schools in Sweden, so to some extent it was necessary to use and adapt data originally intended for higher education.

In order to design the learning activity with respect to both pedagogical and technical considerations the existing learning environment framework also needed to be understood. This required an analysis of design and architecture. The learning activity was developed and integrated as part of the existing framework, which required special consideration and had impact on some design decisions.

The literature review and theoretical background on history didactics and source criticism, together with an understanding of digital learning environments and the application of teachable agents lead to a conceptual design for a learning activity. This conceptual design together with an analysis of the existing framework result in a software design and implementation, see Figure 1.1.
1.6 Thesis Structure

The rest of the thesis is structured as follows:

- Chapter two contains the theoretical background necessary for performing the work in this thesis and summarizes the literature review regarding the history curriculum and source criticism.

- Chapter three covers the pedagogical and technical aspects on digital learning environments and teachable agents, as well as a technical description of the framework for the existing software.

- Chapter four describes the conceptual design and interaction design for the learning activity, as well as explanations for chosen design decisions.

- Chapter five covers the technical software design for the learning activity,

- Chapter six presents a discussion on results and final conclusion, along with suggestions for future work in this field.
Chapter 2

Background

This chapter presents the theoretical background from the initial literature review and covers topics necessary to understand the background of this thesis. This includes understanding the requirements from the national history curriculum, source criticism in a historical context, and how this is taught in schools.

2.1 National History Curriculum and Source Criticism

The Swedish National Agency for Education (i.e. Skolverket) provide a National Curriculum (Kursplan i Historia, 2011) for schools, which provide educational goals that should be met by students each year for achieving the different grades. The curriculum on history for middle grade schools have traditionally covered knowledge of past times, historical events and individuals, as well as the ability to discuss major events. Students should also be aware of terminology used when discussing history. Following the latest revision from 2011, the curriculum now also include goals regarding how to use and discuss the value of different historical sources. Students should now also be able to discuss similarities and differences between historical sources, as well as why those differences exist.

The precise wording regarding historical sources in the National History Curriculum for years 4-6 are

"Eleverna ska genom undervisningen även ges förutsättning att utveckla förmågan att ställa frågor till och värdera källor som ligger till grund för historisk kunskap."

and

"... utveckla sin förmåga att kritiskt granska, tolka och värdera källor som grund för att skapa historisk kunskap."
With grading based on the following text, for the highest grade

"Eleven kan använda historiskt källmaterial för att dra enkla slutsatser om människors levnadsvillkor och för då välutvecklade resonemang om källornas användbarhet. Eleven kan tolka och visa några av historien i vår tid och för väldiga resonemang om varför det finns likheter och skillnader i olika framställningar av historiska händelser, personer och tidstyper."

Summarized in English (my translation)

"The education should provide students with opportunities to develop their ability to critically review, interpret and value historical sources as a base for historical knowledge. They should be able to use historical sources to draw simple conclusions on how people live and discuss in a well-developed manner how the sources can be used. They should be able to use and explain traces of history in our time and discuss in a well-developed manner why there is similarities and differences in descriptions of historical periods, events, and persons."

These goals are general and provide an idea of what the education is meant to achieve. However, the wording provide little insight to how actual source criticism could be taught in low and middle grade schools. School text books generally provide good explanations of basic source criticism, but only a small and varying amount of exercises.

The history curriculum do not make any further distinction between source criticism and the broader and more general term critical thinking. This distinction is commonly made in literature, with critical thinking also including students to further question what powers lies behind statements and actions to attain a deeper understanding of historical events. In a historical context source criticism is a part of critical thinking and this thesis uses the term source criticism as it is used in the curriculum. Though, questions on why a particular source was created, and by whom, are indeed asked when critically analysing a historical source.

Backman Löfgren (2012) writes that students in general are knowledgeable about source criticism and principles for source analysis, but have very little actual experience. She studied and interviewed sixty high school students on the topic of source criticism and shows that the vast majority could account for and explain the basic principles, but that none could apply them in practice. The students were knowledgeable on terminology and criterion used to evaluate sources, but when producing own material still used sources with no or low validity or trustworthiness. Backman Löfgren highlights the teacher’s responsibility and the importance of creating relevant forms for working with historical material. Creating exercises and providing students with practical experience remains one of the more challenging tasks for a teacher in history.
However, the National Agency for Education provide a national test (Nationellt Prov i Historia, 2013), that do provide some insight as to what practical skills students should be able to master. This test is given each year to all Swedish six graders and include source criticism questions.

**2.1.1 National Test - compare and value two sources**

One question to be answered on the test is based on two images, found in Figure 2.1. The task is to explain why you can use one of these images as a source of information on Viking history, but not the other.

Students are presented with an image of skeleton remains along with some pearls and a golden coin. The text describe this as remains found in a grave from the 10th century. The skeleton is from an 8-9 year old girl and the grave was found when excavating the Viking town of Birka.

The other image is of modern plastics toys. There is a Viking long-ship with sails and shields, along with Viking figures complete with horned helmets and tools.

Teacher assessment instructions list several components expected from the answer for grade A. Students should be able to explain some reasons why the grave findings can be used, and why the toys cannot be used. They should also be able to provide insights as to why there might be problems with using the grave findings. The answers should be based on reasoning that is well-grounded on theory on source criticism and historical concepts.

![Att tolka och värdera källor](image)

Figure 2.1: Example from the national test.
2.1.2 National Test - primary or secondary sources

Another question to be answered on the test contain a list of ten historical items. Among the items are a modern photography of a church painting from the 15th century, a comic book with medieval looking images, the original Bridget of Sweden’s Rules of the Order confirmed by the papacy in Rome in 1370, a coin from 1287, and a modern film on 14th century kings and wars.

The first part of this task is to value these as historical sources and mark which of the items could be used as an historical primary source, and which is fully or partly an interpretation of other sources. For the highest grade students should be able to correctly classify nine out of ten items.

In the second part of this task students are asked to choose one of the items and describe in detail what knowledge on medieval times that could be gained from that historical source. For the highest grade students should be able to describe several pieces on information as well as explain why it is possible to gain this information from that particular item. Answers should be well motivated.

2.2 Source Criticism in a Historical Context

All of history is based on interpretations of historical sources, and historical sources and artefacts are continually evaluated based on a number of properties. Some sources might be more reliable than others, and how we value these sources, and based on what properties, is called source criticism. Since history is never an absolute truth, but an approximation set in a context, all historical source need to be interpreted with respect to the context in which it was created.

We can never describe a historic event exactly the way it actually occurred, but with a scientific analysis of sources we can critically review remains, primary, and secondary sources, and provide a mainly correct description, as well as a probable cause for events.

What do we mean when we use the term historical source? A source used by historians to gain knowledge of past times can be described as anything that has been left by past times. It can be a written document, but also a painting, a building, or any kind of small items - a train ticket, or an engraved stone. These sources give us information that add to the sum of our total knowledge of our history. When used in order to draw conclusions or make a point, historians talk about historical evidence. What a source is evidence of very much depend on what conclusions are drawn, and a careful analysis of the source is required in order to determine its value. Figure 2.2 contain examples of historical sources (A painting, a building, an original document, a train ticket).
There are several different ways to approach how to classify and determine the value of a historical source (Eggeby et al., 2002; Garraghan, 1954; Hermansson Adler, 2009; Kjeldstadli, 1998). Common for them all are the most important distinction between primary and secondary sources, where a primary source was created or present during an actual event and a secondary source refers to one or more primary sources. A primary source relates directly to the event it describes, whereas a secondary source interprets and analyses primary sources. Original documents, creative works, remains, relics, and artefacts are typically considered primary sources. For example, an eye witness account of a certain historic event is considered a primary source, whereas a later historian’s analysis of said event is a secondary source. It should be noted that a source can be both a primary and secondary source depending on what aspect is examined. A diary, for example, is a primary source regarding a person’s life, but is often considered a secondary source regarding events mentioned in the writing.

A further common distinction is made between remains and storytelling sources. Remains are physical objects and artefacts, whilst storytelling evidence also include annals, chronicles, and oral tradition. Again, note that many sources are both remains and storytelling (e.g. a diary). When examining remains the primary considerations are authenticity and if the source is representative. Storytelling evidence is more complex and need to be carefully studied also with respect to dependency, time, and tendency.

Hermansson Adler (2009) describe the process of interpreting historical sources as analysing a number of properties on which the source can be evaluated. Source criticism, or source analysis, is described as asking a number of questions: Who is sending a message, and to whom. In what way, to what purpose, and in which context? A distinction is made between different kinds of historical source material, remains, documents and artefacts, but the analysis process generally remain the same. The following descriptions of the four main properties on which a source is evaluated are based primarily on Hermansson Adlers book Historieundervisningens byggstenar: grundläggande pedagogik och ämnesdidaktik from 2009. The book gives a
good coverage of various aspects of historical sources, and it is commonly used for pedagogics and history didactics education in Swedish schools and universities.

1) **Authenticity** *(Swe: "Äkhet")*

Is the source real, or is it fake? This is always the first question asked, since further analysis of a fake source or artefact will prove different. Our own history is full of historical documents, paintings, and artefacts that has been proven to be fakes, created to look like authentic sources for a wide variety of reasons. However, a fake source or artefact, if analysed as such, might also provide useful information on questions such as when and why it was created. It might illuminate aspects of politics and propaganda, or prove to be only a scam for financial gain.

2) **Time** *(Swe: "Samtid")*

How close in time was the source created to the event it describes? This is a very important factor, as information tend to change drastically over time. Oral tradition have a major impact on how a story is told between the actual event and the time when it is finally written. Sources close in time might generally be considered of higher value. This, however, is not always the case and the historian must be careful when assigning a source value based on age alone. A source close in time might also be involved enough in events to be considered a part of them. Later descriptions might be considered more impartial.

3) **Tendency** *(Swe: "Tendens")*

To what degree is the source partial, and why was it created? Even a genuine source, close in time to events, might for several different reasons be considered partial. One can argue that all historical sources are more or less partial since the original creator is bound to have some personal bias, but there are levels of biased information. Especially written sources are prone to show a strong tendency towards a certain side of a story. For example a royal chronicle is written to glorify the royal house and should not be considered an impartial objective source. Historical remains typically are considered less prone to have a high degree of tendency, genuine remains are not partial.

4) **Dependency** *(Swe: "Beröende")*

Is the source independent or does it contain secondary information and interpretations? Dependency mainly deal with the source being a primary or secondary source. When considering a secondary source it is important to relate also to the primary sources that might have been used, and intentional and or unintentional differences. Interpretations and partiality have an impact on retelling of history, but mistakes also occur. On a number of occasions, even bible texts have been changed because of copy or translations errors.
Returning to the examples from the national test in history we can analyze the items based on these properties. The skeleton remains are likely to be authentic and contemporary to the time when they were buried since they were found on site at the excavation of Birka. Remains in themselves tend to be objective and not have a high degree of either tendency nor dependency, and the bones, pearls, and coins can tell us about the conditions at the time in Birka. However, one must be careful to consider if the remains are representative or not.

The plastic toys could also be considered authentic in that they do not give the impression of being something they are not. Looking at them as historical evidence, however, they are not authentic. Furthermore, they are not contemporary in that they have been created in modern time. They also have a high degree of both tendency and dependency, since they were created to entertain with little regard to historical accuracy. Viking representation in these toys are based on hearsay and common misconceptions.

2.3 Adapting source criticism for middle grade

The vast majority of sources describing the historical method and source criticism in the historical context is aimed for high school and higher education, so to what extent do the theory need to be adapted for middle grade schools? It turns out, not much.

Bruce A. VanSledright (2000) finds that ten- and eleven-year olds can learn not only about history, but also to practice history. In his study he asked a number of students to examine and interpret a number of primary and secondary sources related to the American Revolutionary War, a complex mix of sources from both sides. After working with the material under guidance, he concludes that the students learned to effortlessly shift back and forth between conflicting viewpoints and determine when the material could be used to draw conclusions, or not.

Peter Lee (1998) examines differences in children’s ideas of history at different ages. He finds that the older students (school year 7-9) show markedly better understanding of historical concepts such as why sources may differ and why we never may gain full understanding of what actually happened. However, even the younger children (school year 3-6) demonstrated susceptibility to some advanced concepts. Lee stresses the progression of students’ ideas about history from young age. The National Curriculum (Kursplan i Historia, 2011) state that actual concepts and terminology should be used in the education to allow student to learn how to use them. Examples are remains (swe: "kvarleva"), contemporary (swe: "samtida"), source (swe: "källa"), and interpretation (swe: "tolkning"). The terminology should not be simplified.

This shows that middle grade students can use, and is expected to use, and benefit from fairly advanced educational content regarding history and critical thinking.
Chapter 3

Digital Learning Environments

This chapter contains a background on digital learning environments and teachable agents, as well as an overview of the existing history learning environment, hWorld, and its software design.

3.1 Digital Learning Environments

Digital Learning can be described as any sort of learning facilitated by technology that give students at least some element of control over time, place, path and pace of learning.

Correctly used digital learning is enabling in that it puts less restrictions on where and how students learn. Peters (2000) write that several features of digital learning environments are beneficial, but that it is important that the pedagogics also are adapted for the digital environment, that we move from a pedagogics of instruction, and create and implement a pedagogics of enablement. Features of digital learning environments that are enabling include autonomous acquisition of knowledge, and collaborative learning. Homework can be individualized both regarding each students pace and way of learning. An adaptive software may allow students to learn in their own style, making learning both personal and more engaging.

Digital learning, however, is much more than just providing students with a tablet or laptop computer. Digital learning requires a varied combination of technology, educational content and teachers to provide guidance. The technology is the infrastructure that provides a framework only to facilitate digital learning. This could include internet access, hardware such as a computer or smartphone, as well as any applicable enabling software framework. The digital content is the high quality educational and academic material that is delivered using the above technology. The digital content is not
simply a PowerPoint presentation or scanned-to-pdf document, but is interactive. It enables students to do the subject instead of only learning about the subject. Content, however, ranges from simple feedback questionnaires to engaging interactive and adaptive software.

Availability is an important factor for promoting digital learning environments and tools. Once a technical platform is in place, access to a range of digital environments is readily available, both in school and from home. Especially when studying history, access to primary sources and artefacts can be difficult to provide. Having information and tools readily at hand give students time and opportunity to focus on the subject matter at hand. Nygren and Vikström (2013) have shown that students provided with a digital archive for learning history was far more likely to actually review and use the primary source material than students working with a traditional archive. This, in turn, had positive influence over the students’ knowledge construction in the area of history.

In an academic and corporate environment there are successful examples of online courses for self-study, but in a middle grade school context, well motivated educators play an essential role. Technology and interactive feedback-based educational content will most likely change the teacher role to be more of a guide than a central player. Teachers are able to provide more personalized guidance to ensure that students learn and use the technology to assist students learning on their right level. Real-time progress monitoring enables teachers to quickly provide guidance and assistance where it is needed. Backman Löfgren (2012) studied groups of students using digital tools in school working with the history subject. She emphasize the importance of the teacher as a guide. By selecting questions and to some degree limiting students’ options they could stay on track with less risk of diverge from the current subject.

The Swedish National Agency for Education writes in a report (Skolverket, 2009) that it is not enough to buy computers and digital technical equipment, but that the educational content also need to be adapted. The education itself will have to be adapted, but to add value the digital environments also need to be developed for educational purposes and with respect to the educational curriculum. It is equally important that the educational content is adapted for digital learning, as that the digital content is adapted for the educational content.
Possible challenges with developing digital learning environments include indiscriminate use of progress feedback from the digital environment. Lévesque (2006) has shown that students when possible tend to use path-of-least-resistance strategies to overcome perceived obstacles. For example by superficially scanning the material in search for the right answer, instead of learning. Students continuously given feedback on progress and what is done right and wrong might fall into this process of trial-and-error, negatively impacting the actual learning experience. These issues need to be considered and students’ tasks in a digital environment needs to be sufficiently complex to facilitate actual learning.

3.2 Teachable Agents

There exist a large number of digital learning environments based on, or using, various kinds of digital agents. This includes simple learning activities for children as well as professional expert systems for industrial use. The idea behind the use of agents, or virtual characters, is that it provides an increased level of immersion and work as a motivational factor. Traditionally these agents have either assumed a teaching or supervisory role, to assist or guide students and users in their effort.

Almost everyone has some time had the experience of learning while teaching. Some graduate students observe they never really understood a topic until they had to teach it. This pedagogical approach is called learning-by-teaching (LBT) and has been known since ancient time. The philosopher Seneca the Younger wrote in a letter to Lucilius "dicendo discimus", latin for "by teaching, we learn". It has also been shown that students that learn in order to teach others to pass a test in fact do learn better than those who learn in order to pass the test themselves (Barsh & Schul, 1980)(Roscoe & Chi, 2008).

Frager and Stern (1970) describe a study where sixth grade student were instructed as language tutors for preschool kindergarten children. They show that the preschool children receiving tutoring improved their skills as expected but also that the tutoring students improved their test results compared to a control group. The greatest impact where found in the otherwise hard to motivate group of low-achieving sixth graders. By feeling responsible for teaching another smaller child, the students improved not only actual test results, but also "school morale, attitudes, attendance and their feelings about themselves".

A teachable agents (TA) is a way to combine the digital learning environment agents with, and exploit, the learning-by-teaching approach. The idea being that students use the digital environment to learn in order to themselves teach a digital tutee. Chase et al (2009) have shown that the positive effects of the learning-by-teaching approach remain in a digital environment when teaching a TA. The TA also act as a factor to increase motivation and learning (Blair et al, 2007).
3.3 Description of hWorld

Educational Technology Group is currently developing a digital learning environment for teaching history in the middle school, hWorld. The environment is to be used as a platform for evaluation and research on how such digital environments can be developed and used in schools, and how students learn. An important component of this digital environment is the teachable agent. There exist a number of TA-based digital learning environments in areas such as mathematics, for example one described by Pareto et al (2011). This, however, is one the first to explore the subject of history, and is based on the theme of "inventions and discoveries".

This digital learning environment has a narrative that starts with the student being introduced to one of the time elves in the Castle of Time. The student learns that the time elf will in time replace the Guardian of Time, but in order to do so the time elf first needs to show that it can qualify as successor by passing a number of tests. Figure 3.1 shows the Castle of Time with the Guardian of History on the left and the time elf to the right. Unfortunately the time elf gets sick if travelling with the castle’s time machine, so the student is asked to travel through time and learn about history in order to later help teach the time elf. With the time machine the student can visit historical persons, observe historical events and interact with historical objects. The acquired knowledge is used in a number of activities performed with the purpose of teaching the TA enough of history to finally pass the tests. In this process the student takes on the role of teacher and must first learn him-/herself in order to help the TA pass the tests.

![Figure 3.1: The hWorld Castle of Time.](image-url)
The learning activities can be performed in three different modes, where the student can do the activity on his or her own, have the TA watch, or do it together with the TA. The timeline learning activity focus on basic facts where historical persons and events are related to the correct time period by placing them together on a timeline. Figure 3.2 shows the timeline learning activity where the student and TA take turns placing historical persons and events together on the timeline. The TA’s knowledge base consists of a set of facts with associated certainty, and is by default empty - there is no initial knowledge. The TA learns new facts and increase their certainty by watching the student. When doing the activity together the TA only use knowledge gained in previous learning activities. In order to have the TA pass the final tests the student needs to make sure that the TA learns the correct facts with a high enough degree of confidence.

Current learning activities in hWorld cover part of the curriculum for history in middle school, but there is a need for expanded content to study several aspects of learning linked to the curriculum, especially in the area of source criticism. The next chapter presents a conceptual design of such a learning activity.
Chapter 4

Conceptual Design

This chapter describes the conceptual design of the source criticism learning activity, as well as both the pedagogical and technical design decisions that were made, and why.

4.1 Narrative and overall design

The learning activity is located in an exhibit room in the Castle of Time, where the Guardian of History store a number of historical artefacts. The artefacts are collected by the elves during their travels, but unfortunately there also turn up items that are perhaps not very well suited as historical reference. One of the main tasks for the Guardian of History is to sort new items gathered by the elves and determine which items are to be kept or not. The time elf, a teachable agent, needs to learn this job and the student is here to help him. The student will be able to talk to the Guardian of History to learn about source criticism and what artefact properties are useful for determining whether to keep them or not. The task is to browse a selection of historical artefacts and discuss them with the agent so that it later can help sort the items. The time elf need to learn all skills necessary for replacing the aging Guardian of History and need to learn the task and show the Guardian of History that it does know how to perform the task as expected.

After studying artefacts in the exhibit room and learning about source criticism concept, the student and time elf can choose to help sort items in order to learn the task. The student help the time elf build enough knowledge to pass a final test, based on the same sorting activity.
The activity takes place in the exhibit room, as shown in Figure 4.1. The main screen display consists of a number of parts:

A) Guardian of history dialogue
B) Agent dialogue
C) Student dialogue options
D) A number of interactive artefacts

![Diagram of exhibit room and dialogue interface](image)

Figure 4.1: Main dialogue interface for source criticism learning activity.

Browsing the artefacts on display in the exhibit room is done by selecting any of the interactive items. This opens a new overlay with information on that item in the form of both an image and a descriptive text, as shown in Figure 4.2. The description highlights various aspects of the artefacts and describe properties that are used to determine whether this particular artefacts is a good historical source, or not.

### 4.2 Guardian of History dialogue

The primary dialogue involves a number of options selectable within the conversation with the Guardian of History. The dialogue is written with strong focus on keeping the narrative intact. Upon first entry to the room the Guardian of History provides an introduction to the room and the exhibit.
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Figure 4.2: Artefact description information window.

On subsequent entries to the room the dialogue state that there is now a new set of items to help sort. The introduction give the student a good overview as to what is possible to do in this room and what is expected of the time elf. The student is then provided with a choice whether to talk more about source criticism and artefacts properties, browse the artefacts, or try to help sort the items.

The dialogue should be written using actual concepts and words and should not be overly simplified. It should also adhere to the hWorld narrative and attempt to increase student immersion by building the story around the helping of the time elf to achieve its goals. The general dialogue options are shown in Figure 4.3.

Figure 4.3: Guardian of History main dialogue options.
4.3 Artefact properties and selection of artefacts

An artefact can be any kind of historical item, a document, a painting, or an actual item. In this context an artefact will consist of an image and a textual description from which clues can be drawn. The artefact is defined by the four previously identified properties, Authenticity, Time, Dependency, and Tendency. For any given artefact these properties can all have one of three distinct values:

- "Good", e.g. the item is authentic.
- "Bad", e.g. the item is heavily dependent on other sources.
- "Neither", e.g. the item is close in time but not contemporary, or there is not enough information to decide.

Any combination of these three values for the four properties is possible. Only a limited number of artefacts is included in this work so care should be taken so that most properties will assume all values for at least one item.

Artefacts should have a textual description so that it is possible to draw the correct conclusion regarding the artefacts properties. Other aspects of the quality of the artefacts such as the source being a primary or secondary source is also described in this textual description. As with the dialogues, descriptions should also be written to use actual terminology from the field of historical research and not be overly simplified. Terminology used in historical method and source criticism should be used when possible, and not avoided. It is clearly stated in the history curriculum that students should be aware of historical concepts and terminology. This includes wording such as "remains", "contemporary", "source", and "interpretation" (Swe: "kvarleva", "samtida", "källa", "tolkning").

Furthermore, artefacts will be assigned a difficulty value of low, medium or high. This is used within the learning activity to control difficulty level and for giving a sense of progression. For the student this will actually appear as three separate difficulty levels when starting the activity, where only a good result on a previous level will unlock the next. The low difficulty items mainly consist of the same items that can be observed in the exhibit room, whereas the high difficulty items contain markedly more ambiguous textual descriptions.

Figure 4.4 shows an example artefact. This is a fragment of the Westrogothic law, or Västgötalagen. It is the oldest Swedish text written entirely in Latin script and also the oldest of all Swedish provincial laws. There exist multiple independent copies of the text so it can be assumed the writing is authentic. This copy was made in the early 13th century, possibly close to one hundred years after the law was drafted, so it is not close in time, and a copy is by nature dependent on its original as a primary source. A law is not expected to have any specific tendency. For the purpose of this
learning activity this fragment of the Westrogothic law would be said to be "Good" regarding authenticity and tendency, and "Bad" regarding time and dependency.

### 4.4 Source criticism learning activity

When first entering the room the student is provided with a choice of talking to the Guardian of History and browsing the artefacts. This is done with the time elf present in the room, but passive. Once starting the actual sorting activity the student will have the choice of doing the activity on his or her own, or together with the time elf.

The activity selection screen includes the following options

- Student alone, levels 1-3
- Together, levels 1-3
- Student do, agent watches, levels 1-3
- Agent do the test (or student if configured without agent)

Initially only the "student alone" option is available, at level 1. More difficult levels and other activity options are unlocked based on good results in previous attempts, or the time elf having reached a certain proficiency with the items. Feedback is provided when an activity is complete and visual cues provide information on what activity modes and levels are available.
When the agent does the test it is always at the same difficulty level (hard), but with the possibility to get up to three stars based on result. The "best-so-far" result is stored and shown on the selection screen.

The actual source criticism learning activity is based on a number of artefacts placed on a table and the student and/or time elf need to sort the artefacts. The activity takes place over four distinct states, where sorting is performed based on the four selected properties in order (i.e. artefacts are first sorted based on authenticity, then time, then tendency, and finally on dependency). See Figure 4.5.

![Figure 4.5: Source criticism learning activity overview.](image)

Artefacts are clickable, resulting in an informational image and text similar to the one found in the exhibit. There is a help button to assist the student with information on source criticism properties and terminology. Once all artefacts are placed in a box (corresponding to "Good", "Bad", "Neither") general feedback is provided by the Guardian of History, and the activity progresses with sorting based on the next property. After all sorting states are complete, final and more detailed feedback is provided. Upon completion with good result progress is updated and more difficult settings are unlocked.
4.5 Learning activity without TA

In the Castle of Time, students always have the possibility to test their learning activities by themselves. The purpose of this being that students initially can learn about, in this case, source criticism and the artefacts without teaching the teachable agent the wrong things.

As a research tool for studying student and TA behaviour it is also desirable to compare student groups both with and without the teachable agent feature enabled. The learning activity is designed to support a mode where the time elf options are not present at all, with students only learning themselves. This should be configurable at group level. When the time elf is entirely disabled the TA dialogue options are disabled and the visual representation of the TA is not visible.

4.6 TA knowledge representation and dialogue

When doing the activity together with the TA the student have the option to have the agent act passively and only observe, contributing only with naive comments, or have the agent act, comment and possibly argue based on its own knowledge. The purpose of sorting artefacts and having the time elf observe, or discussing them with the TA is to build the agent’s knowledge of the specific items.

Dialogue is written to follow the narrative and hide the actual underlying representation whilst the available answers should still be clear enough to understand their meaning.

The agent’s knowledge representation is two-fold with a specific part and a generic part. The specific part relates to knowledge on specific items previously encountered and discussed. This part is based on a value and a certainty value for the different properties for each artefact. These values are affected by the various dialogue choices the student selects, and feedback provided to the agent when the agent selects. If the student for example would answer that this item is authentic, this would improve the agent’s certainty of that knowledge. If the answer conflicts with the agent’s previous knowledge it would increase uncertainty.

The generic part of the knowledge is based on the agent’s general knowledge of the different source criticism properties and is not related to any one artefact. The generic knowledge is used when the agent is very uncertain about a specific artefact, to simulate the agent might be proficient enough to still make a correct assessment.

Knowledge representation for the agent is illustrated in Figure 4.6.
4.7 Other design considerations

Integration into a larger framework provides both opportunities for reuse, but also impose limiting restrictions. There are other design considerations that need to be addressed when implementing the solution.

4.7.1 Configurable Agent

The learning activity is designed to be configurable with regard to TA behaviour. The lWorld environment is also a research tool and as such there is a need to perform evaluations using different configurations.

The existing solution and learning activities use a configuration file for storing information on TA behaviour, and the same infrastructure is to be used for this work. The configuration file is stored server side and retrieved to the client side on request from the JavaScript engine.

Configurable parameters should include how and to what rate the TA learns, TA dialogue options and behaviour, i.e. to what degree the TA contradicts the student based on its own knowledge.

Different configuration files could, for example, be used for various degrees of "troublesome" agents with varying degrees of argumentation to provide students with increasing challenge of teaching.
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4.7.2 Student behavioural logging

Besides logging internal states and progression to the server and client console logs, the hWorld framework provide a coordinated logging component for logging student activities. Logging is handled through a hWorld log API that stores all log entries server-side in the database.

Log data is used for evaluation of hWorld as an educational tool and for evaluation of students’ learning. Logging should include all sorts of student interactions with the software, what choices are made, how long time is spent on the various activities, as well as information on progression though difficulty levels.

4.7.3 Django Admin API

The Django Framework provides a powerful administration interface for performing maintenance and developing content. The underlying data model is exposed in the admin interface making it easy for non-developers to add content without detailed knowledge of the implementation.

In hWorld, this administration interface is used for adding content and designing the various settings with historical persons and artefacts. A long-term goal is to have teachers and historians add the actual content. Any new data model developed should also be able to modify and add new content to through this interface.

4.7.4 Integration with existing solution

Since this work is to be integrated into an existing solution in which there is a number of concurrently ongoing development projects, care needs to be taken to ensure a minimum of conflicts. This includes but is not limited to:

- Developing and committing source code on a unique source code repository branch.

- Designing and naming database tables to avoid namespace conflicts.

- Designing and naming source code files and global data structures to avoid namespace conflicts.

- Minimize changes to common APIs and common source code files.

- Use common APIs only when necessary in order to avoid cascading changes.

This in turn, requires to implement the source criticism learning activity as a component with only a loosely coupled integration with the hWorld framework. The Django framework helps facilitate this by its modular approach and abstraction layers.
Chapter 5

Software Design and Implementation

This chapter describes the software design, the implementation and testing of the source criticism learning activity.

The source criticism learning activity is designed and implemented as a part of the hWorld framework, which limits the available options regarding development environment and source code language. The hWorld framework, and this activity, is developed as a web-based application on top of the Django application framework and the Model-View-Control design pattern.

Server side implementation is based on a SQL database and Python. Client side implementation is based on JavaScript and HTML5.

5.1 The Django Application Framework

Django is a high-level, free and open source, Python web application framework used for a variety of purposes. The purpose of the framework is to allow developers to focus on actual web application development and help set up a working infrastructure with little effort. Once set up Django provides a secure environment that scales from rapid-prototyping to full-scale deployment.

Django utilizes a backend database, such as MySQL, and optional administration interface used for site maintenance. The framework follows the model-view-controller architectural design pattern, and adhere to the DRY (don’t repeat yourself) principle, common in model-driven architectures. In software engineering, DRY is a principle stating that all application knowledge should have an unambiguous and authoritative representation. When applied successfully a modification of any single element does not require further changes to unrelated parts of the software, especially useful in large
complex projects and for distributed development.

Included in Django is also a default development web server to enable a fast and easy setup of an executable environment.

Figure 5.1 describe the Django architecture with a model layer describing the data and defining it in Python. The view function performs requested actions using templates for controlling how the user sees the modelled data.

Figure 5.1: The Django Application Framework.

Django is maintained by the Django Software Foundation (DSF), an independent organization.

5.1.1 Model - View - Controller design pattern

The MVC, Model-View-Controller, architectural design pattern is commonly used for web applications and is one of the older software design patterns described. The purpose of the pattern is to abstract implementation layers and ensure that changes in the presentation layer have minimal impact on the underlying representation, as well as the other way around. Data and model logic is separated from the user interaction by introducing the controller component, as shown in Figure 5.2.
Figure 5.3 show an activity diagram to explain interaction within the pattern.

- The Model contain the domain specific representation of the application data.
- The View renders the model data to an end-user format for presentation.
- The Controller updates model states and visual presentation based on user input.

In hWorld the server side architecture based on Django is heavily dependent on the MVC pattern. However, some client side functionality, such as the majority of the learning activity logic written in JavaScript, does not strictly adhere to this pattern. It could be described as a logical extension of the control layer.

5.2 Existing hWorld common framework

Using and interfacing with the hWorld common framework provides both opportunities and challenges. Most importantly, there are a number of hWorld features that for different reasons are reused or otherwise affect the implementation of the source criticism learning activity. These components are listed and described here.

5.2.1 Settings and rooms

The hWorld environment is implemented as a number of "settings" - or stages - with a number of unique rooms for each setting. Each room contains any number of interactive persons and/or artefacts and only one room can be visible at any given time. Adding content is primarily done by editing database information through the Django web administration interface.
The Castle of Time is one such setting with a number of rooms, one of which is the new exhibit room. This framework is used for creating the new exhibition room.

5.2.2 Dialogue engine

In hWorld there are a number of dialogues with different persons in different settings. These dialogues are implemented using a dialogue engine based on json data files. The simple format allows a certain degree of freedom in designing the dialogues with nested and circular structures. Dialogues can be triggered by hWorld events such as interacting with objects or persons, and in turn trigger new dialogues.

This dialogue engine is reused for the Guardian of History dialogue with information on source criticism.

5.2.3 Agent configuration file

For evaluating different configurations for the teachable agent in hWorld there are a set of agent configuration files with parameters. These configuration files are reused with new entries regarding this new learning activity.

5.2.4 Logging

There is a hWorld common log API for logging information both in the client and in the server and storing log entries in a database. This log API will be used for storing log entries regarding the activity and student and agent progression. These logs are used as a research tool for evaluating hWorld in a deployed setting with real students.

5.2.5 Django view getEvent

In hWorld there is a Django view getEvent used for scheduling a number of different events. This view have been modified to accommodate for added functionality required for the new learning activity.

5.3 Client frontend

The exhibition room, placement of artefacts and dialogues with the Castle of Time are all based on the common hWorld framework with most new content implemented by adding database entries, and only minimal code changes. The sorting activity is implemented in JavaScript and is described in later sections. JavaScript source code files and other data present in a global namespace is prefixed "SC" (for Source Criticism) or otherwise clearly marked as belonging to this learning activity.
5.3.1 The Exhibit room

The Castle of Time is implemented as a hWorld setting with different rooms, one of which is the hallway which provides access to the rest of the castle. For providing access to the new exhibit room a new door object has been added to the hallway, with a redirect to the exhibit room. The door can be found in the upper left of Figure 5.4. The exhibit room is implemented as a standard hWorld room in the Castle of Time setting. Artefacts and persons were added to the room by adding them in the Django web administration interface.

![Figure 5.4: The Castle of Time hallway.](image)

The exhibit room itself consist of three major parts, the Guardian of History with associated dialogues, the interactive artefacts with information for study, and the table used for the sorting activity. The exhibit room can be found in Figure 5.5.

Each artefact is a database entry that holds information on graphics to be used and location in the room as well as a textual description of the artefact with help on how to interpret that information for evaluating the artefacts properties from a source criticism perspective. Clicking on an artefact opens an informational overlay with this information, see Figure 5.6.
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Figure 5.5: The exhibition room.

Figure 5.6: Artefact information overlay.
5.3.2 Guardian of History dialogue

Interacting with the Guardian of History opens up a dialogue with several possible dialogue options. The dialogues are implemented using the existing dialogue engine based on server-side json data files.

Here the student is told that sorting artefacts are one of all the things the time elf need to learn, and the student are here to help. Dialogues are centered on historical concepts and how to classify artefacts based on four distinct properties, the authenticity, time, tendency, and dependency.

Dialogues are written to adhere tightly to the hWorld narrative. An example can be found in Figure 5.7, with a full dialogue example (Swedish) in Figure 5.8.

Figure 5.7: Guardian of History dialogue.
5.3.3 Mode selection

Interacting with the exhibit room table open a configuration screen were the student can choose how to do the sorting activity. The configuration screen can be found in Figure 5.9. Initially only a few modes and difficulty levels are available, with the rest unlocking based on student and agent performance.

Difficulty level controls the number of artefacts to be sorted and their respective difficulty level. Artefacts considered easy are those found in the exhibit room and are available for study before starting. Artefacts of average difficulty have more ambiguous descriptions and are not very easily classified. Difficult artefacts are even more difficult with complex descriptions. The different activity modes are

- **Alone**

  When the activity mode is set to "alone" the student performs the activity on his or her own. The teachable agent is not present. This mode is for practicing without risk of erroneously teaching the agent.
the wrong facts.

- **Observed**
  The "observed" mode is the same mechanics as the "alone" mode except now the agent is present and learns by watching the student do the activity.

- **Together**
  In "together" mode the student and agent take turns performing the activity. The agent learns by watching and the feedback provided by the student on the agent’s actions.

- **Test**
  The "test" mode is the mode where the agent performs the actual test to show that the gained knowledge is enough to achieve a result good enough to qualify as a replacement for the Guardian of History.

![Figure 5.9: Sorting activity configuration screen.](image)

### 5.3.4 The sorting activity

The sorting of artefacts take place over four separate rounds, one for each property to be sorted by. Properties are authenticity, time, tendency, and dependency. All artefacts are thus sorted four times. Sorting takes place by dragging the artefact to the corresponding box, see Figure 5.10. Once all artefacts are placed in a box the student may continue to rearrange them or click finished to receive feedback. Feedback for each round of sorting is brief, with the Guardian of History only giving a short comment on the overall result, see Figure 5.11. The final feedback is more detailed and contain
summary of the total number of sorted artefacts and how many of these very correctly sorted.

During sorting, artefacts are interactive so clicking them open the same information overlay present in the exhibit room. Inside the sorting activity, however, the student is provided with less information that do not explicitly state the answers.

Figure 5.10: The source criticism sorting activity.

Figure 5.11: Guardian of History sorting feedback dialogue.
5.3.5 Agent client side knowledge representation

When doing the activity in mode "alone", the agent is not present in the room. In all other modes the agent’s knowledge model comes into use. Initially the knowledge is empty. All stored agent knowledge is the result of agent experience together with the student.

The agent knowledge is distributed in two parts, the specific and the generic knowledge. The specific knowledge relates to actual artefacts that have been encountered when watching the student or doing the activity together. The generic knowledge is a competence value for each kind of artefact property, based on how much of the stored knowledge weighted by certainty that is correct.

When encountering an artefact where the specific knowledge is above a certain threshold, the agent’s stored knowledge about that artefact is used. If the specific knowledge is below the threshold the agent falls back on the generic knowledge in an attempt to make a qualified guess. This simulates that the agent has achieved enough generic competence in the field to start using the knowledge in new situations.

When using the mode "observed" the agent passively watch the student, and learn. This is initially the primary way of teaching the agent, since doing the activity together would prove futile given the agent’s initially empty knowledge.

In the mode "together" the student and agent take turn placing artefacts. When the student have placed an artefact the agent comments based on its knowledge. Comments range from "That was new to me", to "Yes, that is correct" and "You are wrong!". This is to provide the student with feedback related to what information is actually stored in the agent’s knowledge base. Future agent configurations could possibly be more or less troublesome, argue even further, and actually move artefacts placed by the student.

When the agent has placed an artefact the student is given the opportunity to provide feedback to the agent, also a source for agent learning. Options are "Correct", "Don’t know", and "Incorrect". The student then have the option to move the artefact placed by the agent, see Figure 5.12.

Agent certainty is increased by watching the student sort artefacts, and by the student confirming agent’s placement when taking turns. Certainty is decreased when the student responds to the agent’s placement with stating that the placement is incorrect.

How the actual knowledge values are updated are configurable in the agent’s server-side configuration file. Configurable parameters include agent dialogue texts, certainty increase and decrease delta values. Knowledge is updated in the client during the activity and stored on the server after completion.
5.4 Django views

The Django views control data flow from the model representation to and from the client web browser, via Ajax calls. A number of new views have been implemented to support this learning activity.

Access to the exhibit room and interactions with artefacts in the room are mainly handled through existing hWorld framework, with a few minor additions. Other views have been implemented to enable smooth transactions of data between the client and the underlying representation.

New views and content in existing views are prefixed with "SC" (for Source Criticism) or otherwise clearly marked as belonging to this learning activity. Naming is in a few cases modified to fit into how similar names are constructed and used in hWorld.

5.4.1 Modifications to existing views

The generic hWorld Django view getEvent is used for a variety of browser events, including redirects to other settings and rooms, as well as initializing dialogues with interactive persons in the different hWorld settings. The events are predefined database entries and usable in the Django admin web interface. This makes it possible to easily connect interactive persons and artefacts in hWorld with event triggers.

This view has been modified to accommodate for opening of the artefact information overlay. A new event type scinfooverlay triggers the request for server data with the image and textual description of the artefact. Upon successful data response, the client opens the overlay with the provided information.
5.4.2 Added views

The added views are all related to the actual sorting activity and data transactions related to configuration of the activity, as well as agent knowledge and artefacts data, and reporting of results after completion. The new views are:

- selectSCActivity
  Renders the source criticism mode selection page and handles responses from that page by returning current mode progress and a redirect to the actual learning activity. Also create progress data if it does not already exist.

- scActivity
  Renders the learning activity, the sorting table and the associated JavaScript engine.

- getSCFacts
  Responds to an Ajax request from the client and returns data on a number of artefacts. The number of artefacts and their difficulty is based upon the current mode and difficulty level.

- updateSCProgress
  Updates the student’s progression for the current mode. Unlock difficulty levels and new modes based on performance.

- getAgentBeliefs
  Respond to an Ajax request from the client and return the agents knowledge for a list of artefacts.

- updateAgentSCBeliefs
  Update agent knowledge data on server based on data from the client. Can also unlock modes based on total correct confidence.
5.4.3 Sequence diagrams

The sequence of data transactions during and after initialization is illustrated below.

![Initialization sequence diagram](image)

Figure 5.13: Initialization sequence diagram.

Figure 5.13 shows a sequence diagram with activity between the various actors once the student clicks on the exhibit room table and initialize the selection of activity mode, up until the activity is fully initialized.

When the student starts the activity selection screen by clicking on the exhibit room table, a selectSCActivity request is sent to the server which returns a table with available modes. The student selects mode which prompts an html post selectSCActivity request. The server redirects the browser to the actual scActivity which contain the activity layout along with a JavaScript engine for running the activity. The JavaScript in turn use getSCFacts and getAgentBeliefs to set up necessary data structures. Once finished the visual presentation is updated and the student can start the sorting activity.
Figure 5.14: Sorting activity sequence diagram.

Figure 5.14 show the continued sequence of events during the actual sorting activity.
5.5 Data model

The database used in this project is a MySQL database with data and tables from the hWorld development server. Database tables designed for this learning activity is prefixed with "SC" (for Source Criticism) in order to keep the namespace organised and maintainable.

5.5.1 The SCArtefact entity

The data model for the source criticism learning activity is centred on a model of an Artefact. It is the artefacts that needs to be analysed and sorted by the student and the teachable agent, and it is the range of artefacts that contain all required information.

An artefact can be used in the sorting stage of the learning activity, and optionally also be present in the exhibit room for more information and learning opportunity.

An illustration of the Artefact database entry can be found in 5.15. The SCArtefact table content are:

- **entity_ptr_id**
  The Entity is the basic hWorld unit; all items in the hWorld design compromised of a set of entities. The name field is used for the artefact name, and the description is a textual description of the artefact, used for gaining clues on how to value and classify a particular artefact. The entity can have any number of associated images.

- **img_path**
  Server side file system path for images.
- **infotext**
  A more detailed description of the item only used for artefacts present in the exhibit room. This text is more helpful and clearly states how an item is to be classified.

- **authenticity/time/tendency/dependency**
  These values define this artefact with regards to how it is classified. It is the true answer with possible values of "Good", "Neither", and "NoGood".

- **difficulty**
  Difficulty is used to select what artefacts to use at a particular difficulty setting.

- **room/xCoord/yCoord**
  These optional values define if and where an artefact is present in the exhibit room (or actually any room). If the artefact is only used in the sorting activity these values are null.

- **triggersEvent**
  Defines what sort of event the browser should fire when a visible artefact is selected. All currently implemented artefacts use an "scinfooverlay" event, prompting a visual overlay with more information of the artefact.

- **defaultAnimLabel**
  Which of the associated images is the default. This is the image used when showing an artefact in the exhibit room.

- **zindex**
  A parameter defining the relative z-ordering of artefacts, which is what artefacts is to be drawn on top of the other. A higher zvalue is drawn on top of a lower.

A number of artefacts have been fully implemented to illustrate how the learning activity is designed. Artefacts have been selected to exhibit a variety of properties. A list of all fully implemented artefacts are found in Figure 5.16. There are also a larger number of placeholder artefacts implemented for testing and evaluation purposes.

Updates and addition of artefact data is done through the Django administration web interface, or by a developer accessing the database. Figure 5.17 show the Django admin interface and data for the example artefact "Viking Ring". The values for the room and coordinate properties tell that this artefact is present in the exhibit room.
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<table>
<thead>
<tr>
<th>Mona Lisa</th>
<th>Viking Ring</th>
<th>Green Man</th>
<th>Westrogothic Law</th>
<th>Trebutchet</th>
<th>Dissertation</th>
<th>Viking Toy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authenticity</td>
<td>Good</td>
<td>Good</td>
<td>Bad</td>
<td>Good</td>
<td>Easy</td>
<td>Good</td>
</tr>
<tr>
<td>Time</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Bad</td>
<td>Moderate</td>
<td>Bad</td>
</tr>
<tr>
<td>Tendency</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Moderate</td>
<td>Easy</td>
</tr>
<tr>
<td>Dependency</td>
<td>Good</td>
<td>Bad</td>
<td>Good</td>
<td>Bad</td>
<td>Moderate</td>
<td>Bad</td>
</tr>
<tr>
<td>Difficulty</td>
<td>Good</td>
<td>Bad</td>
<td>Good</td>
<td>Good</td>
<td>Easy</td>
<td>Easy</td>
</tr>
</tbody>
</table>

Figure 5.16: The fully implemented artefacts with properties.

Figure 5.17: The Viking Ring artefact in the DB admin interface.
5.5.2 Tracking student progress

In order to track students’ progress on the server between sessions there is a new table SCProgress for storing progress. In order to support multiple stored sessions with different configurations for one single student there is an hWorld concept for a stored user configuration. This user configuration is composed of a unique combination of user id and configuration and holds information on what kind of agent is used as well as other parameters. The configurations are currently under development and some content is yet to be defined. A student login session is associated with exactly one user configuration. The hWorld user configuration is here used as the unique identifier for keeping track of student progression within this learning activity.

The progress is stored for combinations of user configurations and activity modes. The activity modes are alone, observed, together, and test.

The SCprogress database table is illustrated in Figure 5.18. The fields in the table are as follows:

- **user_config**
  The current user configuration, user id + configuration data.

- **mode**
  The current activity mode, alone/observed/together/test.

- **level**
  The actual progress indicator, what is the highest level unlocked for this particular combination of user configuration and activity mode.

- **bestResult**
  The best result so far, currently only used for the test mode.

Updates of progress are done server-side based on results reported from client.

![Figure 5.18: SCProgress database table.](image)

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5.5.3 The agent knowledge model

The agent knowledge is distributed in two parts, the specific and the generic knowledge. The specific accumulated agent knowledge is stored server-side in a database table SCAgentBelief. All knowledge is associated with exactly one user configuration through the hiWorld Agent entity. A user configuration can be associated with any number of different agent types. Current implementation only supports "no" agent and the described "teachable agent". Future implementation of this activity might also lend support for various "troublesome" teachable agents currently under development.

For each combination of agent (user configuration) and artefact the table contains entries with unique combinations of facttype and factvalue, as described below:

- **agent**
  The agent (and user configuration) associated with this session.

- **artifact**
  The artefact that this knowledge relates to.

- **facttype**
  What sort of fact this knowledge relates to, possible values are the four parameters authenticity/time/tendency/dependency.

- **factvalue**
  What value this piece of knowledge contains, with possible values Good/NA/NoGood.

- **certainty**
  The certainty value describe how sure the agent is of this particular piece of knowledge.

All combinations are possible, so it is possible for the agent to have conflicting stored knowledge regarding an artefact for a specific type of fact, with different certainty values. There could be stored a certainty value for each combination of factvalue, facttype, and artefact. The table is illustrated in Figure 5.19. Updates of knowledge is done client-side and only sent to server for storage.

The generic knowledge model is not stored between sessions, but calculated runtime for each new started activity. The calculation is based on all stored knowledge for the agent associated with this session. All certainty values for all correct knowledge for a specific knowledge type is added and the certainty values are subtracted, with weighted values and scaling factors. These factors are configurable for each agent in a server configuration file common with the rest of the hiWorld framework. This results in a generic competence value for authenticity, time, tendency, and dependency respectively.
5.6 Software Verification and Validation

The testing of the learning activity started with white-box development test during implementation and was completed with exploratory testing of the final learning activity.

Since there were no planned on-site effect evaluations of the hWorld for the current iteration of development, this were never part of the scope for this thesis.

In order to successfully test the entire learning activity a number of placeholder artefacts were implemented to complement the limited amount of actual content artefacts.

5.6.1 White-box development tests

With no strict requirement specification at the outset of the implementation, verification took more the form of verifying source code and mode logic. Development tests were in effect during the implementation of the activity and based on both server and client console output in order to verify internal states and data consistency. Testing were mainly focused on the JavaScript sorting activity code and the implemented Django views with underlying data model. Browser visual accuracy were not tested at this stage.
Server-side console output and logging was performed via the built-in Django web server. Data logged and verified included usage of Django views and applicable states for these, as well as all database transactions. Tables in the MSQ database were manually verified to have been updated correctly.

Modern web browsers provide excellent developer tools with features for logging and debugging, for example web console output. This console output from the JavaScript were used for verifying the client-side code and included all states and mode changes for the sorting activity as well as updates of server data.

Special focus were put on and care were taken to ensure that the agent knowledge updates progressed as expected through the entire chain.

5.6.2 Exploratory testing

Exploratory testing is a light-weight testing approach that scales well for smaller projects and were found suitable for the validation of this thesis work.

The bases of exploratory testing is that the tester continually optimize the quality of the tests while learning during the process. There is no set suite of tests to perform, and there is no set schedule for what is to be tested in what order. Instead, it is the testers own responsibility to invent test cases and finding defects. This is somewhat dependent on the tester’s experience of testing activities and often in-depth knowledge of the software to be tested, and suitable for product validation.

Applying exploratory testing on the source criticism learning activity resulted in a number of findings that could be quickly corrected. Main focus of the testing were on how the activity worked as a whole, that changes to the configuration files had effect, and that all modes and difficulty levels were unlocked correctly. Multiple browsers were used for testing portability, including Chrome and Firefox for Ubuntu Linux, and Chrome, Firefox and Internet Explorer for Windows 7. Tests were documented in a brief exploratory testing test report.
Chapter 6

Discussion and Conclusion

This chapter contain a discussion on what results were achieved and suggestions for future work, as well as a final conclusion.

6.1 Discussion

This thesis shows that it is entirely possible to build a digital learning activity for teaching students source criticism concepts with the help of a teachable agent. Several concepts have been integrated to provide a valuable platform for future development.

The previous implementation of hWorld did lack support for teaching source criticism. Based on the existing framework the new learning activity focused on source criticism have been integrated in the narrative and add both content and the requested functionality.

The teachable agent provided a challenge when drawing up a conceptual design for this learning activity. As a main feature and research object of the hWorld environment it was important to fully integrate the TA into the activity. This, however, proved difficult to combine with the requirement that the design be fully adapted to the hWorld narrative. According to the narrative the student is here to teach the time elf about history because the time elf itself cannot use the time machine. For this activity the time machine is not used so one might ask why the student is here at all and why the time elf is unable to learn the required skills itself. So, in reality the concept of a teachable agent is only weakly linked to the hWorld narrative for this activity. An attempt have been made to hide this fact by writing the dialogues with emphasis on the student there as a guide to help the time elf.

Source criticism is specifically mentioned as an important area in the national history curriculum and play a vital role in teaching students about history. This learning activity covers some aspect of source criticism by introducing the concepts and trains the student in using them when evalu-
ating a set of actual artefacts. There are, however, a number of important source criticism concepts not covered in this thesis that remain to be implemented for full coverage of the topic. This includes conflicting evidence between similar artefacts as well as potential problems with otherwise genuine artefacts and is detailed in the next section.

There is also a difficulty of classifying artefacts when implementing them based on a few properties and discrete values as have been done here. By necessity the artefacts are either "bad" or "good", which in truth is not always the case. In reality artefacts are more complicated and to fully benefit from the potential provided by this kind of digital learning environment the artefacts should be discussed, for example with the Guardian of History. A more complex discussion would provide an opportunity to delve deeper into the actual meaning of the properties. With the current implementation of this learning activity it is easy to oversimplify facts when implementing new artefacts.

For the same reason, it have also turned out to be difficult to provide "bad" artefacts with several values bad. Not that the field of history lacks fake artefacts, it is riddled with them. But the way the learning activity is implemented provide only a brief text along with an image for each artefact. This is not enough to provide well-written dues for the student to draw conclusions about an artefact being fake. At least not without being too explicit, making the challenge too easy. Regarding sources used for this thesis, history didactics is a well-researched field and while there are variations in how concepts are described the general approach remain the same. The content of the sources used in this thesis correspond well with other research in the field. Digital learning environments and teachable agents are younger fields of research but the sources used here are very consistent in their findings.

In a wider context, there are societal aspects of introducing digital tools, especially in a school environment. In the modern world, the use of digital tools become increasingly more widespread, and knowledge of these tools and how to use them become increasingly important. It could be argued that the use of digital tools decrease and devalue human interactions. But the hiWorld digital learning environment is never meant to replace such a contact, but instead act as an enabling tool. A digital tool can provide continuous feedback to a teachers enabling the teacher to provide feedback where and when it is needed; thus increasing teacher interaction.

There is however, a number of improvements, which were not within the scope of this thesis but that would greatly enhance the final learning activity. These are listed in the following section.
6.2 Future Work

The features and content not developed within the frame of this thesis work have been documented as possible future work. There are two primary groups of possible work, and I have chosen to present them sorted according to this. It is technical tasks and additional content.

6.2.1 Technical

Being a proof-of-concept possible to use for further development there is a number of possible areas for further work. These include

- A more detailed knowledge representation. The knowledge representation is simple and the final learning activity would most likely benefit from a more detailed representation of the teachable agent’s knowledge. Knowledge representation and reasoning is a field of its own within the artificial intelligence research field.

- Evaluation of several conceptual designs. The design implemented in this thesis is limited and would also benefit from being developed in comparison with several alternative conceptual designs.

- Different TA behaviours and levels of "troublesome" TAs. A possible research goal would be to investigate how students react on different TA behaviour and how this impact their learning. Could a troublesome TA arguing for having a break instead of learning possibly increase a student’s motivation?

- The distributed development of hWorld would greatly benefit from automatic testing. However, automatic testing of application heavily dependent on graphical user interfaces are difficult. Finding a framework for automatically testing GUIs and implementing automatic tests would greatly benefit the future development of hWorld.

6.2.2 Content

Besides pure technical additions, this learning activity needs to be further enhanced regarding the actual educational content. Such additions would preferably be done in close cooperation with those knowledgeable in areas of history didactics.

- Additional artefacts. The artefacts currently implemented are for demonstrating the potential of the learning activity and not for education. Additional artefacts could be different and more varied types of objects. For effect evaluation in a school setting several more artefacts need to be added and the existing ones checked for historical accuracy.
- Problematize even "good" primary sources. Even excellent primary sources are often related to at least some sort of difficulty. In this learning activity artefacts are either good, bad, or in between. Never both. In reality an artefact can, for example, be both good and bad regarding tendency, depending on what aspect is investigated.

- Comparing artefacts. Implement a feature for comparing artefacts. A common problem when analysing history is that historical accounts differ, and a goal in the history curriculum is that students should be able to discuss why this is so.

- One example from the history curriculum is the question "What information can be gained from this artefact?". This is an important question and to some extent a summary of the source criticism learning activity. Dialogues could be expanded to involve both the Guardian of History and the TA in discussions on what information could be gained from a particular artefact, what information cannot, and why.

- Other advanced concepts. There are further distinctions to be made regarding whether a historical source can be deemed a good source of information. For example, there is a difference between remains and storytelling sources, and they might need be treated differently. Also, the difference between History and the Past (i.e. interpretation of sources vs what actually happened) is not given enough space in the current implementation. These aspects could possibly be integrated in the hWorld framework with future learning activities.

- Effect evaluation. It remains to be shown to what degree this approach for teaching source criticism in schools are effective. Future evaluations will have to show the extent of any positive effects.
6.3 Conclusion

What I have done in this master thesis was to design and implement a learning activity within the existing hWorld framework, in order to show that a digital learning environment can be used to help teach students about source criticism concept in the history subject. An important aspect of digital learning environments is the anchoring in the curriculum, and this work shows that it is possible to develop activities well anchored in the pedagogical theory of history didactics. During this work I have shown what principles are used for teaching source criticism and how to use these principles to effect within the digital environment.

The learning activity does indeed support students in acquiring skills for analysing historical sources based on common principles for working with historical sources. By using the concept of a teachable agent the implementation demonstrates one of many potentials of digital environments.

There are several limitations in the current implementation that need further development and content additions before this can be used as an educational tool in schools. The purpose, however, was never to implement a final solution, but rather a working conceptual design and implementation to be used as basis for further development.

However, it remains to be seen whether or not this particular approach is effective when it comes to evaluation with actual student in schools. Based on current research I feel confident that is the case, but this is left to future continuations of this thesis.

In a modern information society, source criticism in itself is vitally important, and by learning this skill early on students will find it easier to apply in different fields. History provides very suitable grounds for examining and teaching these skills early on.

Bruce A. VanSledright (2000) describes and summarizes why source criticism is important and why critical thinking is a useful tool to give students, and I end with quoting his finishing words.

"Teaching students to read, analyze, and interpret documents as historians do instills a powerful form of critical cognition and awareness in young people. It’s not hard to imagine that, in a world now dominated by the flow of information, where it is increasingly difficult to discern supportable claims from spurious, these children will have a distinct evaluative and cognitive advantage."
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