Work, Trade, Learn: Developing an Immersive Serious Game for History Education

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Abstract. History education often struggles with a lack of interest from students. Serious games can help make learning about history more engaging. Students can directly experience situations of the past as well as interact and communicate with agents representing people of the respective era. This allows for situated learning. Besides using computer screens, the gameplay can also be experienced using immersive Virtual Reality (VR). VR adds an additional spatial level and can further increase the engagement as well as vividness. To investigate the benefits of using VR for serious games targeting the learning of history, we developed a serious game for desktop-3D and VR. Our serious game puts a player into the role of a medieval miller's apprentice. Following a situated learning approach, the learner operates a mill and interacts with several other characters. These agents discuss relevant facts of the medieval life, thus enabling the construction of knowledge about the life in medieval towns. An evaluation showed that the game in general was successful in increasing the user's knowledge about the covered topics as well as their topic interest in history. Whether the immersive VR or the simple desktop version of the application was used did not have any influence on these results. Additional feedback was gathered to improve the game further in the future.

Keywords: Serious Game, Immersive Learning, History Education, Situated Learning, Interest.

1 Introduction

"Those that fail to learn from history are doomed to repeat it."

- Winston Churchill

While maybe not in quite the dramatic way that Churchill meant most history teachers would agree that learning about history is very important. However, history education suffers from the issue that past times can neither be demonstrated nor experienced directly. While museums might allow for the development of a certain understanding especially when populated with actors, they still cannot entirely recreate the past. Other teaching materials might be even less vivid and often purely consist of texts. Hence, history lessons are often seen as very boring, dry, and not very interesting by students.

In contrast to textbooks, video games do have the potential to present nearly any subject in an engaging and vivid way. The mechanics of video games can be used to encode the knowledge of history lessons to create what is commonly known as a serious game [32]. Serious games utilize the entertaining aspects of video games for educational purposes by turning learning content into the central game element. Besides using regular computer screens, the gameplay can also be presented in immersive Virtual Reality (VR). In the case of history subjects, VR allows users to spatially explore and directly interact with situations of the past, thus nearly realizing time travel. This can allow learners to observe past situations, get in social exchange with agents, and construct knowledge about past eras.

To investigate the potential of immersive serious games for history education, we developed a game putting the learner into the role of a medieval miller's apprentice. This enables situational learning about life in the Middle Ages. In an evaluation, we compared the game's desktop-3D to its VR version to find out to what extend the degree of immersion influences learning and what lessons can be learned for the development of these kinds of applications.

Fig. 1. Picture of the interior of the real mill in the franconian open-air museum in Bad Windsheim on which part of the game was based.

2 Related Work

Serious games are not only developed for entertainment, but also serve the purpose of teaching players about the game's topics [32]. This can be achieved by encoding the knowledge within game mechanics [23]. This means that the information that players are supposed to learn is packaged in a gameplay element where this knowledge is applied [4]. This approach has already been used for educational games for several topics, like transformations in 3D spaces [24]. Some commercial games also implement characteristics of serious games like for example Kerbal Space Program [33] which lets users build rockets using real physics to calculate their flight.

2.1 Learning and Interest

Serious games and VR both allow users to feel like they are present in a virtual environment and situations. This can be helpful for situated learning which indicates that learning is always situated in a specific environment, including a specific social context [17]. This means that both the physical situation as well as the social context in which knowledge is obtained is important. This concept is based on the theory of constructivism which says that "Knowledge is constructed in the mind of the learner" [8]. This means that a learner's knowledge is constructed by themselves through their own experiences.

The theories of constructivism and situated learning indicate that new information is best learned in its natural context where learners can make their own experiences with the learning content. This is especially difficult in history education since it is very difficult to experience history in its natural context, as time travel, is sadly not possible or at least not feasible for educational settings.

As previously mentioned history education can suffer from a lack of interest from students. Interest can be defined as a "psychological state characterized by focused attention, increased cognitive and affective functioning, and persistent effort" [2]. Different types of interest can be differentiated like individual, situational or topic interest. Situational Interest is "interest, which is evoked by certain features or characteristics of stimuli" [14]. Situational interest can be helpful when teaching about topics that students do not have much individual interest in [7]. Topic interest describes the interest in a certain topic. It can be shaped by both the learner's individual interest as well as the situational interest for the learning situation [1]. Interest in general was shown to have a positive effect on learning outcomes [27]. Therefore, the application should present the learning content in an engaging and vivid way, thus evoking a higher interest in the learners. While serious games in general can present learning content in an engaging and vivid way [20], providing a higher immersion can further improve these qualities [31].

2.2 Immersive Technology and Learning

Immersion according to Slater and Wilbur is "the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant" [30]. It can also be defined as "the boundaries within which [presence] can occur" [29].

Presence is defined by Skarbez et al. as the feeling of "being there" in a virtual environment [28]. There are many different definitions of presence but for simplicity's sake, this paper will focus on the provided definition [19].

According to Steuer [31] immersion can be further broken down into the components vividness and interactivity. Vividness describes the representational richness of the environment. Interactivity describes the extent to which users are able to modify the content and shape of a virtual reality in real-time.

A wide variety of different immersive learning applications has already been developed for a variety of topics. Although most immersive learning applications are designed for computer science and engineering topics and have university students as their target audience [13].

There has also been some research into which factors can influence learning in VR or serious games. Dengel and Mägdefrau [9] presented a framework, that describes presence as the central factor influencing learning, which is in turn influenced by immersion and personal factors of the user. Jensen and Konradsen [16] investigated several studies and found that immersive technologies can improve learning outcomes, especially when conveying visual or spatial information. But higher immersion can also lead to lower learning outcomes because users can be distracted by the virtual environment or get motion sickness if implemented badly. They also found that the quality of the investigated studies in general was below average, so it is not sure how reliable these results are. Ritterfeld et al. have shown that more interactivity can improve the learning outcomes in the context of serious games [26].

This research shows that interactivity can enhance the success of serious games, while the influence of immersion still needs further research. However, since both serious games and higher immersion can improve the engagement and vividness, the influence of both concepts must be tested individually.

2.3 History education with Serious Games and Immersive Learning

Different serious games have already been developed to teach about history [3]. One example is the Roma Nova project which recreates ancient Rome and enables players to explore the city and interact with different people there [25]. One commercial game which also has a similar topic is "The Forgotten City" [21], in which players can learn about life in ancient Rome and mythology, by also talking to different characters and hearing about their life.

Although most VR applications are designed for other topics there have also been some immersive learning applications for history education. But many of these applications are not fully immersive and are only for desktop computers. A large portion of these applications are also simple reconstructions or virtual museums which do not offer much interactivity [6]. Dong et al [10] for example developed an immersive VR application where users could experience a medieval tannery which was highly immersive but it did not offer any way to interact with the virtual environment. Ijaz et al [15] on the other hand developed a game where players could explore the ancient city of Ur and interact with many different people. While this application offered a high level of interactivity it did not use immersive VR and was instead playable on a desktop PC. Overall it can be said that there is still a lack of immersive VR applications for history education that offer meaningful ways to interact with the virtual environment.

3 Design

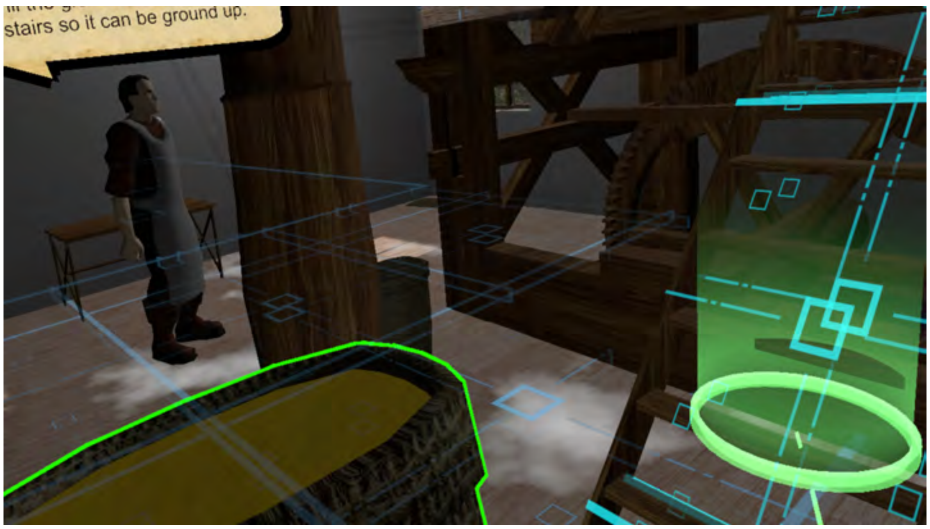

Fig. 2. A screenshot of the VR version of the game showing the mill scene. The teleportation interaction and the highlighting of objects can be seen.

Based on this analysis of previous work, providing a serious game in immersive VR should improve the learning of historical facts. By allowing learners to immerse themselves in the current situation of a person in the past, they can construct knowledge about this era. Also, by providing agents as conversational partners, a substitute for a social interaction becomes possible. This fulfills the core requirements for situated learning. Finally, using an immersive VR serious game should provide the learning content in an engaging and vivid way, thus potentially increasing the overall interest in history.

To test these assumptions an immersive serious game was developed, by expanding a previously developed learning environment [12]. The game is designed for history lessons in 7th grade secondary school education in Germany and its contents were modeled after the official school curriculum.

In order to fit into the lesson plan of these history lessons the following five topics should be covered in the final application:

1. Life in medieval towns
2. Work of a medieval miller
3. Religion and Protestantism
4. Invention of the printing press
5. Medieval cures for the plague

For this purpose, 10 questions were designed with two questions per topic. The learning goal was that students should be able to answer those questions after playing the game. Since the developer of the application was a student from a computer science background a pre-service history teacher helped designing these questions.

3.1 Game Mechanics

Since interactivity can improve learning outcomes and increase interest by making learning more engaging different game mechanics for interacting with the virtual environment were developed.

Players can pick up different objects, like a bag of flour or a loaf of bread, and carry them around to use them later. Other objects are static and can only be interacted with, like a lever for starting the mill. These game mechanics can be used to operate the virtual mill and learn about its core mechanics. Simultaneously, the game mechanics recreate and hence demonstrate the work of a miller in the Middle Ages.

Since the social context is also important for situated learning the player can also talk to different characters embodied by virtual agents. They can initiate conversations with them by approaching them and can make choices about what to say to the characters at different points in the conversation. These interactions are used to make the player solve different tasks, like trading flour for bread at the market and learning about the life of different people in the Middle Ages.

Finally, we used the game mechanics to encode learning content that the game should teach. Which of these game mechanics is used to encode which information can be seen in Table 1.

Table 1. Table showing in which part of the serious game each topic is encoded.

Topic	Encoding
Life in medieval towns	Dialogue with baker
Work of a miller	Task in mill scene
Religion	Dialogue with priest
Printing press	Dialogue with priest
Cures for the plague	Dialogue with priest

3.2 Narrative

The game follows a short narrative where the player takes on the role of a medieval miller's apprentice and experiences a shortened version of a typical

Fig. 3. A screenshot of the Desktop version of the game showing the mill scene. The miller character gives instructions to the player.

day in their life. When the game starts the player hears the call of a rooster and has the choice to stay sleeping or wake up. Depending on their choice the miller is either angry at them or proud of them. Independent of his mood he tells the apprentice that a farmer brought over some grain to be turned into flour. He then instructs the player step by step on how to turn it into flour and explains how the mill works.

Afterwards he sends the apprentice to the market with a small bag of flour in order to trade it for bread. The player then goes to the market in the town square where the baker tells him about life in the city. After giving the baker the flour, he has to wait until the bread is ready and hears a priest talking about cures for the plague. When approached the priest talks about the plague, the invention of the printing press and how Martin Luther's followers split from the catholic church until the baker calls the apprentice back over. He then takes the bread and returns to the mill where the miller sends him back to sleep after eating dinner.

3.3 Scenes

The locations that the player visits during the game are represented by four different scenes. The Mill scene consists of the main mill room, the apprentice's bedroom which also functions as a storage room and the entry hall. The doors to all other rooms of the mill are closed so the player cannot get lost. The mill is filled with several flour sacks and there are flour stains on the floor. Through a small door in the main room an outside area can be entered overlooking the mill wheel. The mill is modeled after a real mill which is currently located the

Franconian Opn-Air Museum in Bad Windsheim. The virtual mill was largely modeled after the state of the real mill except where the current state did not reflect the time period presented in the game.

The second scene consists of a market in a town square in a small town. In contrast to the mill this town square is not based on a particular town but rather the general layout of a town square in the Middle Ages. It contains multiple market stalls with different objects for sale. The square is surrounded by houses and filled with different characters, including some of which can be interacted with, like a baker and a priest.

The third scene is largely identical to the first mill scene, but the time of day is evening and there are fewer objects that can be interacted with. The last scene is a small tutorial scene to learn all interactions. It consists of an empty room with a small platform and two objects that can be interacted with.

Fig. 4. A screenshot of the Desktop version of the game showing the market scene.

4 Implementation

Based on this design the final game was developed. How this was done is described in the following.

4.1 Tools

All objects used in the game were modeled in Blender or taken from free asset packs from the Unity asset store. Out of these objects the different scenes were then constructed in the Unity game engine version 2020.3.14f1. The SteamVR framework was used for implementing the interaction in VR. Two versions of the application were developed: One using immersive VR with an HTC Vive Head Mounted Display (HMD) and one to be used on a simple Desktop PC with a keyboard and mouse.

4.2 Agents

Since the interaction with the people of the Middle Ages is an important part of this game virtual agents to represent the people in the virtual world had to be added. These agents were created from two modular asset packs bought form the Unity asset store. These agents include characters that can talk to the player like a miller, a baker, and a priest as well as multiple different background characters in the market scene that can not be interacted with.

All talking characters' dialogue was fully voiced by friends and colleagues. Using authentic medieval accents was considered but in the end modern German was used in order to make the dialogue more understandable for players. In addition to the spoken dialogue clips, speech bubbles were displayed over the characters' heads so players can also read the dialogue. These speech bubbles were visible even through walls and always rotated towards the player to improve legibility. The crowd in the market scene had no recorded dialogue but a crowd noise audio sample was used to simulate them talking to each other.

4.3 Interaction

Two different interaction systems were developed, one for each version of the game.

In the VR version players can interact with the application using the HTC Vive controllers. They can move around by physically moving inside the tracking space or teleport by clicking the controllers' touchpad and pointing to where they want to teleport to. Players can grab objects by touching them with the controller and pressing down the trigger. Dialogue choices can be selected by touching speech bubbles with the controllers. Smaller objects can be put into the bag around the avatar's waist by pulling them into it and pulled out again by grabbing them out of the bag. Possible actions are always shown next to the controllers.

In the Desktop version players can interact with a keyboard and mouse. They can move around by using the WASD or arrow keys. They can look around by moving the mouse. They can interact with and pick up objects by left clicking on them. Picked up objects can be dropped again by right clicking. Dialogue choices are selected by left clicking on speech bubbles. Smaller objects can be put into the bag by left clicking on it while carrying an object and retrieved again by left clicking on the bag again. Interaction possibilities are shown next to the crosshair. Which objects should be interacted with to progress the story are highlighted in green in both conditions.

Fig. 5. A screenshot of the dialogue system in the Desktop version of the game.

5 Evaluation

The game was then evaluated in a study to see if it was successful in conveying the learning content to the participants and increasing their interest in history. Additionally the VR and Desktop versions were compared in order to see if the level of immersion influenced these results. The study was conducted in a between-subjects design where each participant used only one version of the game, either VR or Desktop. We randomly assigned the participants to one of the conditions.

5.1 Participants

Participants were recruited from students who received course credit for participation. 38 people took part in the evaluation, with 19 participants per condition. The mean age of participants was 22.61 (SD=2.57) years. 29 participants identified as female, 8 as male and 1 as neither. 36 participants spoke German as their native language while the 2 remaining were business fluent. Only 4 participants used VR weekly or daily. 30 had only experienced VR in studies or never at all. 12 participants played computer games weekly or daily, while 11 had only experienced computer games in studies or never at all. All participants used computers daily or weekly.

5.2 Measurements

The participants' knowledge of history was measured with a knowledge test that was designed with the learning goals of the application in mind. The test consisted of 10 questions with 2 questions per covered topic. Participants took this test before and after playing the game. The pre-test featured 5 questions (1 per topic), with the post-test containing the remaining 5. Which questions appeared in which test was randomized for each participant in case some questions were easier than others.

The knowledge test was repeated 2 weeks after the study in an online questionnaire. Which questions appeared in this questionnaire was randomized independently of the first two tests.

The topic interest was measured with a questionnaire from Ferdinand [11] in the version adapted by Baumgartner for the topic of history [5] before and after playing the game. The situational interest was measured with a questionnaire from the same source only after playing the game. At the end of the questionnaire participants were also asked two open questions about what they liked about the game and what they would like to improve.

All questionnaires were presented digitally on a laptop via Limesurvey [18].

5.3 Hypotheses

Playing the game should increase the participants' knowledge about the covered topics as well as their interest in the topic. A higher level of immersion should further improve engagement and vividness, thus leading to higher situational and topic interest as well as learning outcomes. Therefore the hypotheses are as follows:

- H1: The participants answer more questions in the history test correctly after playing the game.
- H2: The participants' improvement in the history test is higher in the VR condition than in the Desktop condition.
- H3: The topic interest for history is higher after playing the game.
- H4: The increase in topic interest for history is higher in the VR condition than in the desktop condition.
- H5: The situational interest is higher in the VR condition than in the Desktop condition.
- H6: The participants answer more questions in the history test correctly two weeks after playing the game than before playing the game.
- H7: The participants' improvement in the history test after two weeks is higher in the VR condition.

5.4 Procedure

For the study a laptop was used both to fill out the questionnaires as well as run the application. For the VR condition an HTC Vive HMD was used. For the Desktop condition the laptop was used with a keyboard and mouse and a pair of headphones.

At first participants were greeted by the experimenter and sat at a desk where they could read the study information and sign a consent form on paper. Afterward they moved to a laptop where they filled out all pre-questionnaires.

After finishing the questionnaire, they played the game. The exact procedure varied between conditions. In the Desktop condition they stayed at the laptop and only put on headphones. In the VR condition they had to stand in the middle of the room and put on the VR headset and were handed the VR controllers. Before starting the full application, they played a short tutorial. In the tutorial all controls and possible interactions were explained to them by the experimenter and they could try them out. When they indicated that they understood all controls the game was started. When they finished the game's story it closed by itself and they then continued with the post questionnaires on the laptop. Once they finished it, they were thanked for their participation and their e-mail address was collected in order to send them an additional online survey at a later date. After the participant had left all used hardware was disinfected and the room was aired out for 15 minutes, due to the study being conducted during the corona pandemic.

2 weeks after participating in the study each participant received a link to an online questionnaire with an additional knowledge test to check for differences in the retention of the learned knowledge. Of the 38 participants that participated in the main part of the study 34 also filled out this additional knowledge test.

6 Results

The results of this study were evaluated with R in R-Studio.

6.1 Knowledge Test

To analyze if the game increased the participants' knowledge of history the results of the knowledge test of the pre- and post-tests were compared to each other. Since a Shapiro-Wilk test did not show any signs of non-normality ($W = 0.96, p = 0.16$) a t-test for paired samples was calculated. The knowledge test results in the post-test ($M = 3.39, SD = 1.27$) were significantly higher than in the pre-test ($M = 1.66, SD = 1.08$) ($t(37) = 6.113, p < 0.001$).

To compare the test results between the conditions the difference between post- and pre-test was calculated for each participant. This difference in knowledge test results was then compared between conditions. A Shapiro-Wilk test did not show any signs of non-normality for the Desktop ($W = 0.92, p = 0.11$) or VR condition ($W = 0.96, p = 0.63$). Since a Levene test did not indicate unequal variances ($F = 2.95, p = 0.09$) as well an independent samples t-test was calculated. The increase in knowledge scores did not differ significantly between the Desktop ($M = 1.95, SD = 1.28$) and the VR ($M = 1.53, SD = 1.76$) condition ($t(36) = 0.82, p = 0.42$).

6.2 Knowledge after 2 Weeks

To investigate if the knowledge test scores are still higher after 2 weeks the scores before using the application are compared to those two weeks after the study.

A Shapiro-Wilk test indicated non-normality ($W = 0.91, p < 0.01$). Based on this a Wilcoxon signed rank test was calculated. The results in the test after 2 weeks ($M = 3.00, SD = 1.11$) were significantly higher than in the pre-test ($M = 1.74, SD = 1.09$) ($Z = 6.5, p < 0.001$).

The scores directly after playing the game were also compared to the scores after 2 weeks. A Shapiro-Wilk test indicated non-normality ($W = 0.93, p < 0.05$). Based on this a Wilcoxon signed rank test was calculated. The results in the test after 2 weeks ($M = 3.00, SD = 1.11$) were not significantly different from the scores in the post-test ($M = 3.32, SD = 1.30$) ($Z = 217, p = 0.13$).

To compare the results after 2 weeks between conditions the difference between test scores before the application and 2 weeks after using the application is calculated. These differences are then compared between conditions. A Shapiro-Wilk test indicated non-normality for the Desktop ($W = 0.87, p < 0.05$) but not for the VR condition ($W = 0.92, p = 0.17$). Therefore, a Mann-Whitney U test was calculated. The increase in scores did not differ significantly between the Desktop ($M = 1.32, SD = 0.98$) and the VR ($M = 1.2, SD = 0.98$) condition ($U = 149.5, p = 0.81$).

6.3 Topic Interest

The topic interest scores for history of the pre- and post-tests were compared to each other. Since a Shapiro-Wilk test did not show any signs of non-normality ($W = 0.96, p = 0.23$) a t-test for paired samples was calculated. The topic interest scores in the post-test ($M = 20.8, SD = 5.54$) were significantly higher than in the pre-test ($M = 19.58, SD = 6.03$) ($t(37) = 2.58, p < 0.05$).

To compare the topic interest in history between conditions the difference between the post- and pre-test results was calculated and those were compared between conditions. A Shapiro-Wilk test did not show any signs of non-normality for the Desktop ($W = 0.96, p = 0.62$) or VR condition ($W = 0.92, p = 0.12$). A Levene test did not indicate unequal variances ($F = 0.05, p = 0.82$). Therefore, an independent-samples t-test was calculated. The difference in pre- and post-questionnaire scores did not differ significantly between the Desktop ($M = 1.47, SD = 2.66$) and the VR ($M = 1.05, SD = 3.25$) conditions ($t(36) = 0.43, p = 0.67$)

6.4 Situational Interest

The situational interest scores were compared between the two conditions. A Shapiro-Wilk test did not show any signs of non-normality for the Desktop ($W = 0.93, p = 0.18$) or VR condition ($W = 0.96, p = 0.62$). A Levene test did also not indicate unequal variances ($F = 0.18, p = 0.67$). Therefore, an independent-samples t-test was calculated. The situational interest did not differ significantly between the Desktop ($M = 31.58, SD = 5.30$) and the VR ($M = 29.11, SD = 5.60$) condition ($t(36) = -0.88, p = 0.38$).

6.5 Negative Feedback

The most commonly mentioned aspect that participants would like to see improved was the application's graphics, which were mentioned by 11 participants. 5 participants wanted more interactive elements and 4 wanted more content in general. 3 people criticized the controls of the application, independent of which condition they used.

6.6 Positive Feedback

The most commonly mentioned aspect that participants liked about the application was the controls, which 10 people in total mentioned. These mentions were evenly split between the two conditions. The tasks in general, the virtual environment as well as the characters and their dialogues were mentioned by 8 participants each as a positive point. 4 people mentioned that they liked the highlighting of objects that can and should be interacted with.

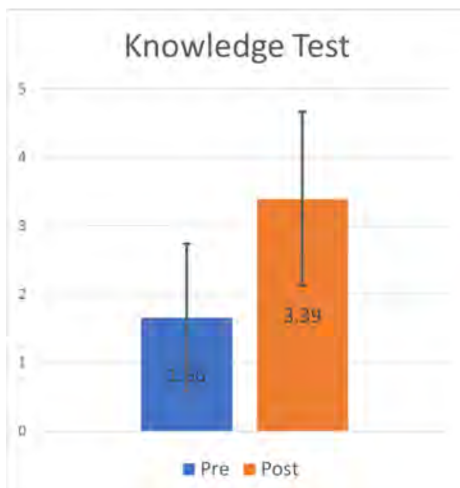

Fig. 6. Results of the knowledge test before and after using the application. Error bars indicate standard deviation.

7 Discussion

7.1 General Effectiveness

The results show that the serious game was successful in increasing the knowledge and interest in the topic of history (see Fig. 6). Hypotheses H1 and H3 can therefore be accepted. Since there is no significant difference between test scores directly after playing the game and 2 weeks later the increase in knowledge seems to persist even some time after playing the game. H6 can therefore also be accepted. Our results thus indicate that the application achieved its goals of teaching users about life in the Middle Ages and increasing their general interest in history.

Although there was a general increase in the participants' knowledge the results of the post test could still be better since only 3.39 out of 5 questions were answered correctly. In order to determine what the reasons for this were a closer look was taken at the percentage of correct answers for each individual question. It could be seen that the questions to which the answer was not clearly stated in the dialogue and instead only implied were the ones with the lowest amount of correct answers. This means that in order to learn important information through this kind of dialogue based mechanics the knowledge should be presented as clearly as possible.

7.2 Influence of Immersion

Which condition was used did not seem to make any difference on the results of the knowledge test as well as topic and situational interest scores. The remaining hypotheses (H2, H4, H5, H7) therefore have to be rejected. It can therefore be assumed that the level of immersion does not have any influence on these learning factors, at least in the context of this specific game. This is not very surprising since learning is very challenging to measure with many factors influencing it and often did not show any significant differences in other studies comparing different kinds of media [22, 34].

Immersion having no effect on the results may not be what was hypothesized but that is not necessarily a bad thing. Considerung the rather rare availability of HMDs at most schools, our results indicate that our serious game can still safely be intgegrated in teaching concepts by only using the Desktop-3D version without risking to lose positive aspects of a higher immersion. Yet, it cannot be guaranteed that there are no other learning benefits of the VR version that were not covered by this evaluation, like general motivation or the players' emotions.

7.3 Limitations

The main target audience for this game are 7th grade students in a German secondary school. Since an evaluation with school students was difficult to organize during the covid pandemic the study was instead conducted with university students. The results may therefore not be fully generalizable for the target audience, because university students might have more previous knowledge about history. Since most students came from technology centered courses of study the general attitude towards using technology for learning may also be different. To make sure that these results are also applicable for the actual target audience the study should be replicated with 7th grade students in the future.

One possibility to help players better remember the knowledge would be to give them the ability to choose what they want to talk about with the characters instead if just having them talk about everything in a predefined order. This would also enable them to repeat the important dialogue so it can be listened to more than once. Additionally this would add more interactivity to the dialogue mechanics which was something participants of the study wished for.

7.4 Further Development

Feedback indicates that players liked interacting with the agents and the interaction with the environment in general. This means that using virtual agents for interaction is generally a good idea for this kind of serious game. This should be kept in mind when expanding the game or when developing similar applications.

Since participants wanted more interactive elements and more content in general the game could be expanded further in future versions. But when adding additional content the context of a school lesson has to be kept in mind. If too much content is added the game may not fit into the timeframe of a single school lesson anymore, especially since some time for the introduction of the topic and the technology is needed. But these problems could be fixed if players had the choice of just experiencing parts of the application or continuing where they left off last time.

8 Conclusion

In this paper an immersive serious game for learning about life in the Middle Ages was presented. This game is designed for use in history lessons in school or as an exhibit in a museum. A first evaluation showed that the game was successful in conveying the learning content and increasing topic interest of the users. The level of immersion on the other hand did not seem to have any influence on the players' knowledge or interest.

Feedback showed that people especially liked the interaction with the other virtual characters. Most users wanted even more interaction and wished for more content in general. From the results and feedback some general guidelines for developing serious games for this context could be gathered:

- Important information should be presented as clearly as possible
- Players should have the option to repeat important dialogues

In the future this game may be improved even further based on the gathered feedback and developed guidelines, and more features might be added for future versions. An improved version of this game can be used in history lessons in schools or as an exhibit in a museum.

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