Please quote as: Thillainathan, N.; Hoffmann, H. & Leimeister, J. M. (2013): Shack City – A Serious Game for Apprentices in the Field of Sanitation, Heating and Cooling (SHaC). In: Informatik 2013 - Virtuelle Welten und Gamification, Koblenz, Germany.

Shack City – A Serious Game for Apprentices in the Field of Sanitation, Heating and Cooling (SHaC)

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Abstract: Apprentices in the field of sanitation, heating and cooling face the problem, that in addition to everyday lessons they have to be at the customer's location to help the craftsmen accomplishing their orders. A proper exam preparation is thus not given as they have to study during idle times or after work. This frequently decreases also the motivation to learn. To support their studies, we have developed Shack City, a story based serious game, which lets apprentices in the field of sanitation, heating and cooling study playfully during exam preparation. The first idea of the game was modeled with GLiSMo (Serious Game Structure and Logic Modeling Language) – our domain-specific modeling language for serious game development. Based on these models, we have implemented a first version of Shack City that is currently evaluated with the guild of master craftsmen.

Introduction

In Germany in 2010 over 250.000 people were employed in the field of sanitation, heating and cooling (SHaC), generating a turnover of approximately €27.8 Billion. At the same time, a total of approximately 35.000 apprentices are trained to become SHaC-Technicians [Ze11]. Their apprenticeship is, as it is the norm in Germany, double tracked: apprentices go to school and receive a "theoretical" education and work with their training supervisors on the location, i.e. often at a customer's property. One of the drawbacks of this system is that often no proper time for exam preparation is given. Forcing apprentices to study during idle times at work or after work at home then leads to a lack of motivation and apprentices quickly forget what they have learned. In order to identify possible ways to support the apprentice training, we conducted qualitative interviews with three experts from the field of SHaC about general problems of SHaC education and training. These experts confirmed the above mentioned statements and the main implication from these interviews is that the education in this field could benefit greatly from a possibility to study the learning matter independent from time and location constraints and in a matter that makes studying enjoyable and motivates apprentices.

Serious games have great potential to fulfill these requirements, as they allow to present educational content in a fun and entertaining manner [Br10]. Educators are able to integrate learning objectives into a game-like environment, which help keeping the player's

motivation to continue playing and learning at a high level throughout the exercise. As this is the main objective for trainings such games are highly sought after in educational contexts, making serious games a big asset for didactics [BS09]. Modern technologies enable not only to address the user on an intellectual level, but also to stimulate all of his senses [DBB12]. Furthermore, it has been shown, that offering learning material through a game rather than presenting the same content using a classical, non-computer based approach has positive effect on the learning success [Pi07]. Mouaheb et al. (2012) name the following as characteristics for serious games. A serious game (i) is a learning process, (ii) is a game, (iii) is an application of video game technologies, (iv) targets multiple learning objectives (to teach, train, educate, heal), (v) applies in almost every field (education, health, advertising etc.) and (vi) is intended for all age groups (children, adolescents and adults) [Mou12]. We hence conclude that serious games can be an effective tool to transmit educational content to apprentices.

While serious games do offer a wide range of opportunities for education, they do come at a price though. Combining educational content with game elements in a computer program requires the coordinated effort of multiple experts. First, the educational content has to be selected and prepared by a domain expert, in our case SHaC, who also has at least some experience in didactics. Second, game elements supporting the educational content have to be identified and selected, hence requiring someone with experience in game design. Lastly both the educational content as well as the game elements have to be combined and implemented in a computer game, thus requiring the cooperation of a programmer. To overcome this obstacle, we employ GLiSMo (Serious Game Structure and Logic Modeling Language), our domain-specific modeling language for serious games. GLiSMo allows non-programmers to describe the structure as well as the logic and behavior of a serious game in a model rather than having to write code.

In the scope of this research, we have worked together with the Guild of Master Craftsmen for SHaC engineers to transfer existing learning materials to a game setup. Based on these models, we have implemented a first usable version of Shack City – a story based mobile serious game for apprentices in the field of SHaC – and currently plan the evaluation of the game in a pilot setting with the guild in near future. This paper is organized as follows: first we give an introduction to GLiSMo. Next, we focus on Shack City and describe how we have elicited requirements for the game by conducting semi-structured interviews with three experts involved in apprentice training. Hereafter, the conceptual design of our game is described. We give an insight into a part of the structure and logic model of the serious game and subsequently go into the implementation part of the game. Finally conclusions are given followed by an outlook of future work.

GLiSMo – A Domain-Specific Modeling Language for Serious Games

To understand our modeling language for serious games as well as the development process of Shack City, we will give a brief description of Model Driven Development (MDD). MDD is a generic term for techniques, which allow the generation of software from formal models. Here, Domain-Specific Modeling Languages (DSMLs) play an important part as they are used to formalize the structure, behavior and requirements of

an application for a specific domain [Sc06]. Model Driven Development for serious games has several benefits for the developer. Using DSMLs allows the developer to focus on creating models representing didactical goals and frees them from the task of worrying about technical details. This induces to easier code maintenance and documentation of games, which is highly desirable [KWB03].

In the following we will give a short introduction into the Serious Game Structure and Logic Modeling Language (GLiSMo) - a domain-specific modeling language, which we have developed to model serious games. Structure modeling includes how a serious game is built, whereas the logic describes the behavior of a serious game.

Serious Game Structure Modeling

The serious game structure contains different aspects of a serious game - the layout of the game world, characters and objects as well as how the player interaction takes place. GLiSMo's structure modeling elements will be presented in the following by describing each element and how it has been derived requirements found in literature. Figure 1 gives an insight into the meta model of GLiSMo's structure modeling, which describes the elements and their relationships. The first element named *Serious Game Root* is the point of origin for all other elements. All elements directly or indirectly connected to this root element belong to one serious game.

Acts and Scenes: Act elements are similar to levels in common games and directly connected to the serious game root element. These acts are divided into one or more scenes and play an important role within the story having several goals. A scene represents one specific place within the game world. These elements are derived from the following sources ([YCG10], [An10], [GAD02], [Wi09], [YLK10]).

Objects: Object elements are used to represent objects in the game world with which the player can interact with or which are used as decoration within the game world. Examples for objects are doors, boxes, trees or other special objects that will enhance the skills of the player. This element is derived from the following sources ([An10], [KKB10], [KM04], [YCG10], [ZS10], [Pr01b], [YLK10], [LC10]).

Characters and Inventories: The player and other social beings representing Non Player Characters (NPC) in the game world are modeled with character elements. These characters can be defined for the whole serious game, for acts only or for a specific scene. Besides this an i*nventory* element is for storing objects taken by the player. The stored objects can be used at a later time within the game progress. These elements are derived from the following sources ([Pr01b], [YLK10], [An10], [LC10]).

User Feedback and Rewards: To give feedback on players' actions, we have introduced the element named *feedback manager*. This manager is responsible for the textual feedback given to the player. For example feedback to the performance after completing tasks is given through the feedback manager. In contrast to this the so called *reward manager* controls the scoring and rewarding within a serious game. Rewards are used to

motivate the user to continue playing the game. These elements are derived from the following sources ([YCG10], [Mo08], [Wi09], [ZS10]).

User Interface Management: The management of audio and video playback is given by the *Audio Manager* and *Video Manager*. These multimedia files are used to play audios and videos as intro and outro of a game, an act or a scene or on specific actions or events. These elements are derived from the following sources ([GAD02], [ZS10]). The *GUI Manager* is used to display buttons, textboxes, scores or the game menu. This element is derived from the following sources ([KKB10], [KM04], [LC10], [YCG10]).

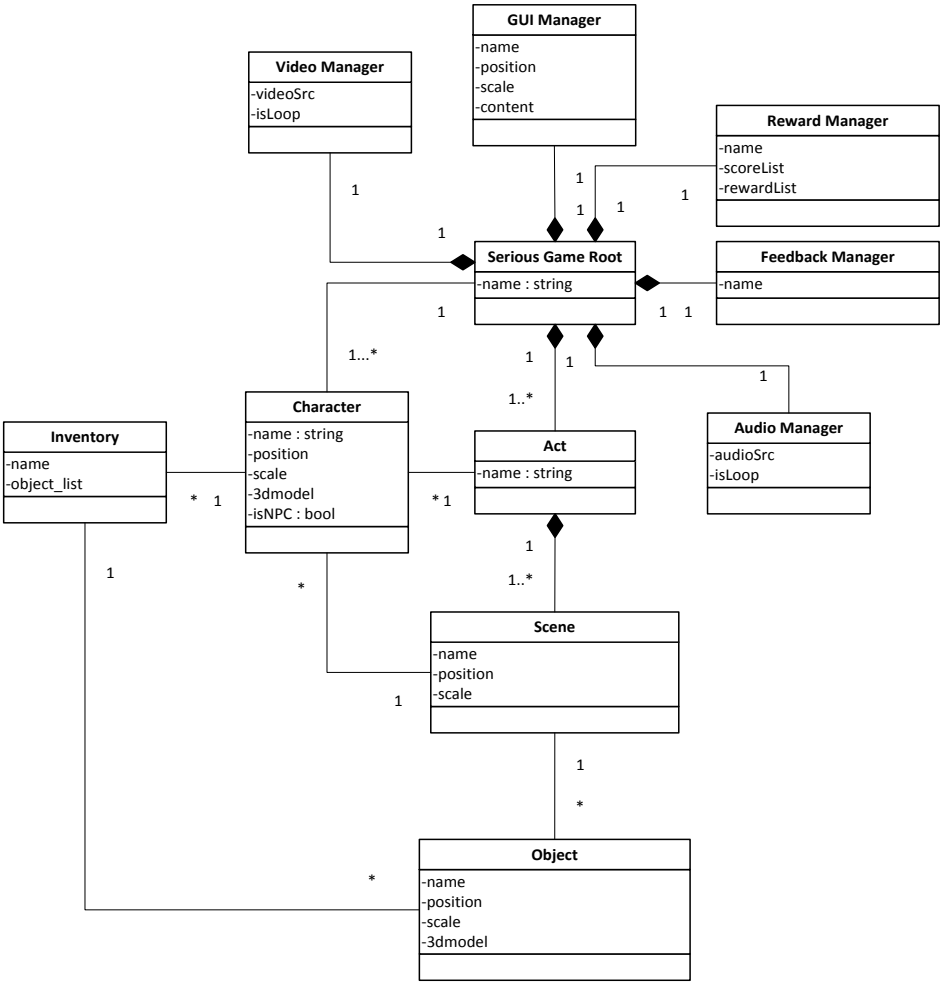

Figure 1: Meta model of the structure modeling elements of GLiSMo

Serious Game Logic Modeling

Serious game logic modeling characterizes the behavior in terms of how does the game react on specific actions performed by the player, or events occurring during game play. Furthermore, assessment of player actions and adaption according to the assessment results are also part of the logic modeling. Here again we have derived the logic modeling elements from requirements found in literature.

States: We define an initial and end-state element to mark the boundaries of a logic model, as already known from UML activity diagram notation. First is represented by a black circle; latter by an encircled black circle.

Actions, Assessments and Adaptation: *Action* elements represent a mechanism to enable the player to interact with the game world. Here, we distinguish different types like *select object, use object, put object, take object, discussion with character*, which represent player-world interaction methods. This element has been derived from the following sources ([Pr01b], [GAD02], [YLK10], [YCG10], [Pr01a]).

Through *task* elements different tasks like multiple-choice questions will be modeled. These are a prerequisite for the *assessment* element, with which the evaluation of the tasks will be done. Assessment is also used to initiate processes to give feedback and achievements to the player. Both, the task and assessment elements are derived from the following sources ([KKB10], [KM04], [LC10], [YCG10], [Mo08], [Wi09], [ZS10]).

Adjusting the learning content and its difficulty to the player's skills, by monitoring the player's learning progress is described in the following sources ([Mo08], [YCG10], [Pr01a], [GAD02]). One way to realize adaption is by letting the player select the difficulty level at start and presenting a predefined game content based on this selection. Another way is to provide different tasks with various difficulty levels and dynamically chose the right task on the basis of previously scored points.

Information and Control Flow: *Streams*, arrows with continuous lines, are used to manage the information and control flow by connecting the elements. Whereas dotted arrows represent *events and messages*, which will be sent between elements. To model parallel and branched flows we use *fork and join* as well as *branch* elements.

Development of Shack City

To create the mobile serious game supporting apprentices in their exam preparations – named Shack City – we took the role of a developer working with experts from the SHaC guild of craftsmen as customers. As the first step in the development process, we elicited requirements for Shack City by conducting semi-structured interviews, based on existing training materials, with three experts involved in apprentice training. Overall, we were able to extract four basic requirements for the mobile serious game from the experts' answers. (1) The application should represent the reality, so that the learner is faced with a realistic situation in which the learnt skills can be transferred and used. (2)

The learning content should base on the given learning material, which is already been used during exam preparation. (3) Soft skills, which are needed in the course of customer interaction, are also characteristics which should been trained. For example how they have to react to different customer types. (4) The experts also mentioned, that different tasks from the learning materials including assignments and scores should also be given, so that the learner is motivated to continue using the application.

Integrating learning objectives into a game-like environment increases the player's motivation to continue playing. Because of higher motivation, apprentices would even learn by playing the game after work. Furthermore, a mobile version of the game for smartphones and tablets would even allow the apprentices to play the game during idle times at work. So, the more fun the game is, the more the players will learn, since they use the game more often and intensively. The requirements mentioned above were used to develop our serious game for apprentices. To meet requirement 1 we have decided to let the game take place in a virtual city with several customers. As in real life these customers have different characteristics. Requirement 2 states that the learning content should base on the given learning material. To meet this, the given customers in the game have different problems with their sanitation, heating and cooling. With this a relation to the reality can be established by presenting customers with individual problems and solutions from real life. To train soft skills like customer friendliness as demanded by requirement 3, the game is conducted by a story based on dialogues between the player and customers. This supports in many ways to present realistic situations in the game world. Finally, to meet requirement 4 the game will have several tasks inbetween the dialogues. Each task will provide an assignment, feedback and scores after solving it. To get the learning content as well as the tasks, we first used this resource [Uh11] to extract tasks as this book is mainly used for exam preparation in the field of sanitation, heating and cooling. Since the extraction of suitable tasks is not possible in this book, we changed our approach. Our pilot partner has provided a set of tasks with best practices from their own experiences in the field. So, we focused on this and made tasks for the game from these best practices.

As mentioned before, we have developed our serious game on the base of models generated with GLiSMo. Basically, Shack City is about the main character, an apprentice from the field of SHaC, who accompanies his master craftsman to different customers to solve their problems. The game and its story are set in a city with several inhabitants having different problems with their sanitation, heating or cooling. These problems are divided into one or more learning objectives. By interacting with the customers, a brief description of the customer's problem is given. At first a dialogue between the apprentice and the customer will be shown, where the customer describes his problem. Next the apprentice tries to find out solutions for that problem by solving several tasks in the form of answering multiple-choice questions, highlighting certain previously defined spots on images or filling missing parts in images. Each level offers alternately dialogues and tasks to solve. After finishing all tasks a page with detailed information about the solved tasks will be shown to give a feedback about the learning progress of the player.

Conceptual Design of Shack City in GLiSMo

Based on the initial brief idea of our serious game for apprentices, we modeled the structure and logic of the Shack City in GLiSMo. The concrete structure model consists of the following elements: (i) serious game root, (ii) different acts representing customer orders, (iii) scenes belonging to the acts and (iv) characters. In Figure 2 an excerpt of the structure model of Shack City is presented for one customer named *Kundin Maschberger*. The associated act is directly connected to the serious game root element and contains two scenes. This is given so that based on the story of the game, different locations can be used. Besides the character representing the trainee played by the player, there is also an NPC acting as the master craftsman. These character elements are connected to the serious game root element as they can appear in all parts of the game. However the NPC, representing the customer associated to this specific act, is connected to the act as this character only appears in this act.

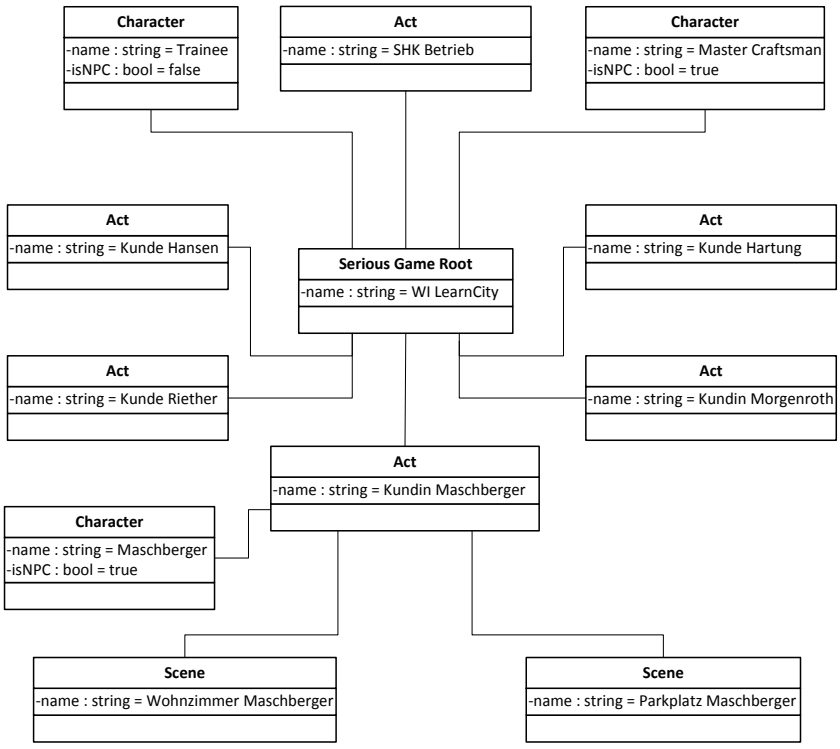

Figure 2: Structure Model of Shack City focusing on *Kundin Maschberger*

After finishing the structure model of Shack City, we have modeled the logic of the game. Figure 3 shows an excerpt of the logic model representing the part of customer *Kundin Maschberger*. Basically there is an alternating sequence of conversations between characters, tasks and assignments. In the given example the conversation deals with the problem context, where the customer describes what has to be repaired at her

place. This is supported by an interesting background story, giving the player more details about the problem. As soon as a decision has to be taken during these dialogues, the player will face tasks. Shack City includes three types of tasks, which will be described further in the following implementation section. After finishing a task the assessment will be done by giving feedback and scores.

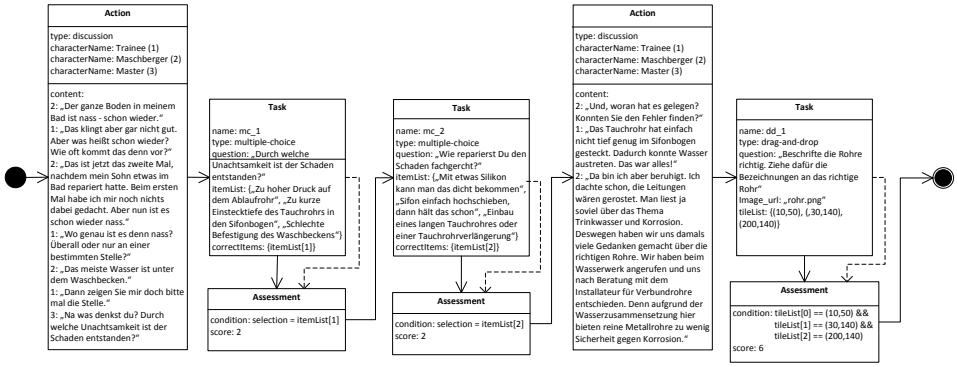

Figure 3: Logic Model of *Kundin Maschberger*

Implementation of Shack City

Our serious game for apprentices in the field of sanitation, heating and cooling is based on our conceptual design described in the previous section. The application has been developed and implemented in a first version as a web application using HTML5, JavaScript, PHP5 and CouchDB as the database, so that the game can be played on mobile devices like smartphones and tablets. The starting point of Shack City is a view on a map of a city, which contains several customers with orders. The player, who represents an apprentice, is providing customer service with the help of a master craftsman represented by a non-player character (NPC). Each customer displayed on the map is having different orders covering various topics of sanitation, heating and cooling (see Figure 4a). As described in the structure model presented in the previous section, these customers map to the acts.

As soon as the player selects one customer, a brief description of the customer and his order will be shown. This overview summarizes background information, problems as well as the tasks of the customer, which helps the player to decide, if he wants to serve him. As soon as a customer has been selected, the game starts. The situation begins with a conversation between the player and either the master craftsman or the customer and follows the logic model described above. So, the player will face several conversations and tasks to complete the customer. Figure 4b shows how conversations will be presented. The characters will be animated, so that the look and feel of a conversation is given. Through conversations the problem context and additional information to solve the following tasks are given.

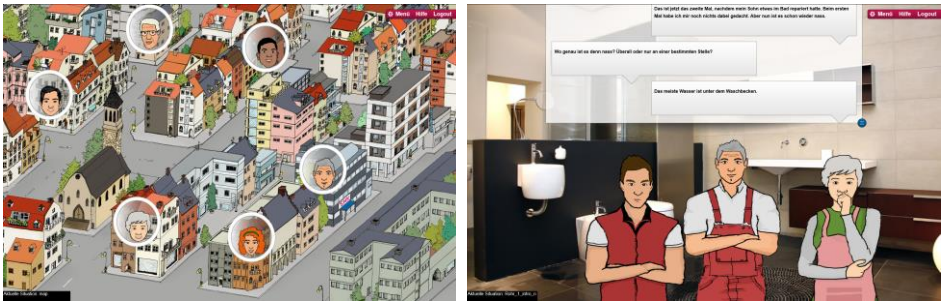

Figure 4: (a) Map view of Shack City with several customers (b) A conversation between the player, the master and the customer

At this stage of the development our serious game has three types of tasks implemented: (i) *multiple-choice question*, (ii) *drag & drop* and (iii) *error location*. In *multiple-choice* questions a question will be asked and several answers or statements will be given (see Figure 5). In the first variation of this task the player has to select one statement, which is right. In the second variation, several statements are correct and have to be selected by the player by marking all correct answers. After selecting one or more statements, a visual feedback will be shown to the player. The correct answers will be highlighted in green. In the next version of this game, a textual feedback will be given, explaining why the given answer is incorrect. Furthermore, all tasks will include scores, so that the player can collect points for each correct answer.

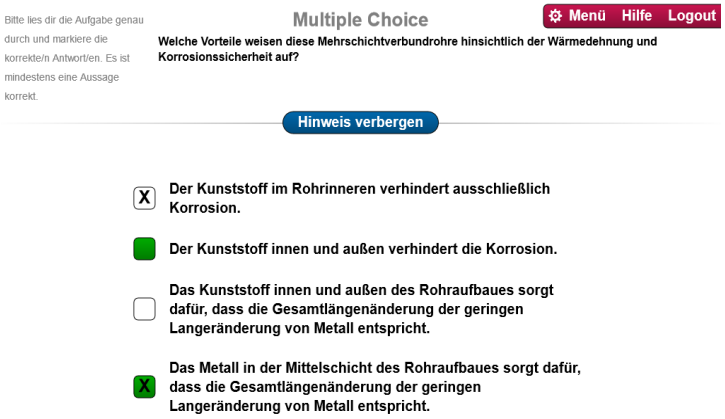

Figure 5: Task type *multiple-choice* and its assignment

Another task type implemented in Shack City is *drag & drop*. Here, a question, an image and some associated image fragments are given. The task of the player is to drag the fragments and position them on the correct position in the image. After finishing this process a visual feedback will be given, where the player gets to know which fragments are positioned correctly (see Figure 6). *Error location* also has a question and an image, but the task here is to find specific positions within the image. These can be mistakes shown in the image or specific parts which are relevant and have to be highlighted. Fig-

ure 7 shows an image, of a machine, which has built in a wrong component. The task here is to point out the wrong component by clicking and marking it.

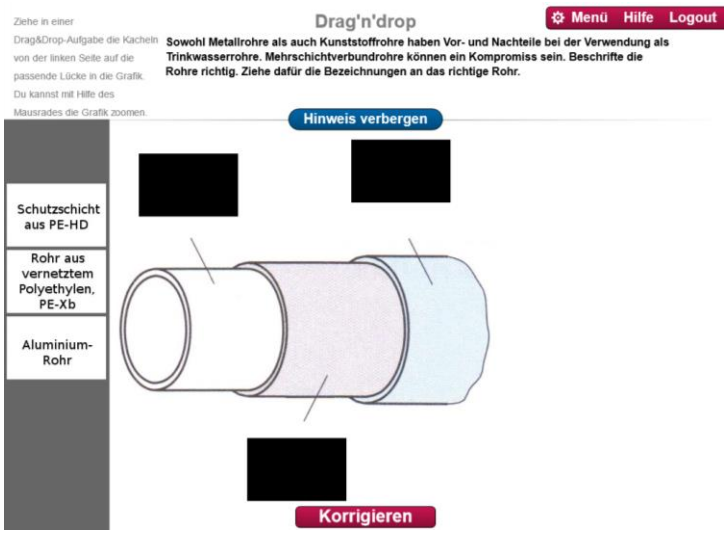

Figure 6: An example for the task type *drag & drop*

Each customer has a sequence of conversations and tasks as described in the logic model presented in the previous section. After finishing the whole sequence that customer is completed and the player can go on to the next customer. Initial tests of Shack City with users show us, that the game has big potential to be very useful during exam preparation. As a next step, we are preparing for a brief evaluation of the game with apprentices from the field of sanitation, heating and cooling. Currently, Shack City contains six different customers having various problems. The amount of different situations (like conversations and tasks) varies for each customer, whereas the lowest amount is 8 and the highest is 37.

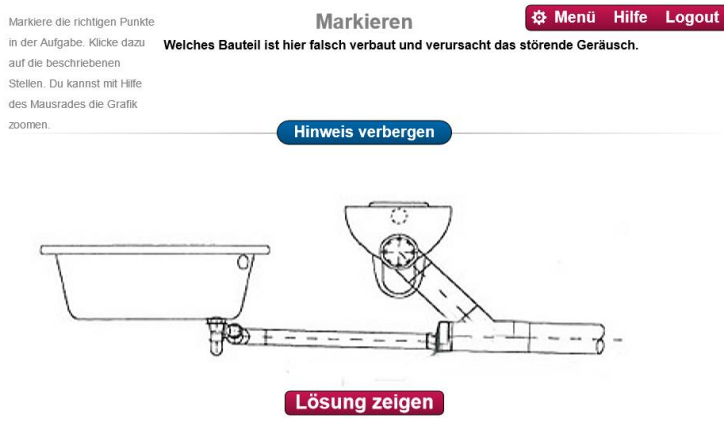

Figure 7: An example for the task type *error location*

Conclusion and Future Work

In this paper we have presented Shack City, a story based serious game for apprentices in the field of sanitation, heating and cooling. The main idea of this game is to support apprentices during their exam preparation. To develop Shack City we conducted interviews with domain experts from the guild of master craftsmen in SHaC to elicit requirements and used GLiSMo, our domain-specific modeling language for serious games. We modeled the structure as well as the logic of the game, so that based on these models the game could be implemented as a web application for mobile devices. With this first version of Shack City we showed, on the one hand the feasibility of the serious game itself and on the other hand that our MDD approach is feasible for the modeling and implementation of serious games.

Future work is comprised of various steps to evaluate the game and improve its functionality further. First we are planning to extend the game by adding new types of tasks. This will provide a wider choice of tasks, making it easier to transfer educational content for the instructors and making the use of the application more interesting. As described earlier we took the role of a developer using GLiSMo, since our modeling language is still under development. To let non-technical domain experts develop serious games without our influence, we are developing an editor for this specific game, so that the instructors themselves can include new contents easily.

Another major part of future work is the evaluation of the game in a pilot setting with apprentices. We have divided the pilot study into two phases. The first phase encompasses the preparation for the study, where initially feedback to the implementation of the learning content will be gathered. Here, the aim is it to determine whether the given tasks and especially the pedagogical concept of the game are valid by collecting feedback from experts in the guild of craftsmen. At the same time, a small set of users will do functional tests with Shack City, to verify that the technical realization of the application is working properly and that the game can be used on different devices. In the second phase, the actual pilot study, we plan to evaluate the complete game in a real-life context with apprentices in the field. To achieve this we will deploy the game to the apprentices of our partner guild of master craftsmen, so that they can use our application to train their skills. As the intention of this serious game is to increase the learning success and motivation of apprentices, we aim to evaluate whether the use of the game has significant effects on the learning success and motivation using pre- and post-treatment questionnaires checking knowledge gain and asking about the learner's attitude.

This research is funded by the German Federal Ministry of Education and Research and the European Social Fund in the project BlendedContENT (www.blendedcontent.de), FKZ 01PF08022A

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