Game Development Projects – From Idea Generation to Startup Activities

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Abstract

Game industry has traditionally applied the latest available technologies actively since the 1970s and 1980s. Game development tools have reached a level in which gamified solutions with specific learning outcomes are realistic topics to be implemented by student groups. As a result, highly sophisticated and cost effective game development tools have been utilized at Turku University of Applied Sciences. We have found that these tools open new possibilities for higher education institutions to further develop their project-based engineering studies. In this paper, we will describe how student groups have succeeded and which kind of challenges they have had in using game development tools while working closely with their customers from various fields such as healthcare, education, and technology industry. Results show that CDIO Standards 5 and 6 can be applied even in game development projects which are a combination of art and technology and thus not representing a field of traditional engineering education.

Keywords: *Learning Outcomes, Game Development, Project-Based Learning*.

1. Introduction

Game development tools have reached a level in which gamified solutions with specific learning outcomes are realistic topics to be implemented by student groups. Quite many game project courses have been organized so that they comprise a part of computer science education and games as an interesting topic has been used as a motivation method to entice students to become interested in software engineering (cf. [1] [2]). According to Zagal & Sharp [3], the use of game development tools in project courses offers an authentic industry-like work experience. In addition, they have found the use of Unity game engine as a useful development tool in projects in which rapid prototyping and Scrum methods have been applied successfully. We have also found that game development tools can open new possibilities to further develop project-based engineering studies [4]. We noticed that especially assessment criteria were challenging to apply based on CDIO standards. Project topics varied greatly and a few groups focused only on content production, which was not at the center of the course. In addition, one group was missing a real customer, which caused challenges in customer assessment. Furthermore, another group was coordinated by other students.

In this paper, we will focus on describing the second implementation of the Digital Media 2 course with a focus on gamified solutions. The first round results have been reported in [4]. In that paper, we mainly focused on the assessment. We will now report how student groups have succeeded in using game development tools while working closely with their customers from various fields such as healthcare, education, and technology industry. We have utilized problem-based learning and CDIO methods just like in the first implementation. Actually, our curriculum has been developed systematically based on the CDIO standards. For example, the problem-based learning implementation of the first semester course in Product Development has been organized successfully since 2007. [5] Totally six groups of students participated in the Digital Media 2 course from autumn 2013 to spring 2014. One of the groups was building an edutainment game called Build a Solid Wall. This game will be reported in this paper in detail. Other games or gamified solutions, - namely a recycling game, a historical application using augmented reality, gamified artistic work, a gamified reminder application, and a treasure hunt tourist

guide - will be described and analyzed at a more general level. In this paper, we will show that CDIO Standards 5 and 6 can be applied even in game development projects which are a combination of art and technology and thus not representing a field of traditional engineering education (cf. [6]).

2. Idea Generation

In the first implementation, we found that students should already contact customers in the first period [4]. At the same time, we have seen challenges in this approach especially if students do not have enough knowledge and self-confidence to meet a potential customer in the early phase of the course. To meet a customer too early is also a critical factor for the university itself because customer relationships have been established through our staff active cooperation with a local industry. Thus, there is a risk that students meeting a potential customer too early can cause negative impact on customer relationships. Based on these reasons, we decided that students should still study all the required content before meeting potential customers.

After the first implementation, we also considered whether students should find their customers or whether they should work with customers negotiated by the teacher. We decided that students will still choose a customer from a list we have compiled. In this way we are able to crop the focus on projects based on our criteria we have in the course. Simultaneously, we are aware of the fact that students miss a chance to participate in these fruitful negotiations on potential topics. By keeping negotiations quite simple before the projects start we try to compensate for this. We have also seen that our RDI activities frequently generate cooperation requests. Quite many of these requests contain activities which are more or less suitable for student projects. In some cases, we have found that a customer has no or relatively small budget for a challenging development project. If we are not able to find a student group which can independently work, we are able to utilize our game development experts who have the latest know-how in game development tools.

The first period (8 weeks) of the current Digital Media 2 course was arranged as in the first implementation [4]. Students were studying game development by using the Unity game engine. The only difference was that this time we introduced potential customers a little earlier. This time we organized a seminar in which potential customers (totally ten) were able to present their idea to the student in 30 minutes: Augmented Reality Application (serious game company), Build a Solid Wall (our university), Augmented Reality Game (University of Turku), IndustrySim (serious game company), Interactive Art (private person), Multiplatform Avatar (startup company), Nagger (private person), Recycling Game (consortium of companies), Turku Treasure Hunt (software company), and Web Game Application (game company). We tried to find to potential customers from various fields. In every case, the topics should somehow have game-related objectives. In some cases, the focus was more on game technologies such as Interactive Art (indoor positioning and audio design) or Turku Treasure Hunt (GPS positioning and speech recognition) or Augmented Reality Game (augmented or virtual reality and QR codes). A few cases focused more on game development such as edutainment games: Build a Solid Wall, Recycling Game, and IndustrySim. In addition, two serious games for health care were introduced: Multiplatform Avatar, and Nagger.

After these presentations, the students were asked to write a short document about the game idea they liked most. Students had the chance to name the three most interesting presentations. Based on the selected six most interesting projects based on students' opinions, the selected projects were: Build a Solid Wall, Augmented Reality Game, Interactive Art, Nagger, Recycling Game, and Turku Treasure Hunt (will be presented later in detail).

We placed students to these project groups based on their preferences and profiles (a programmer or a graphic designer). Basically project groups were formed so that every group had 4-6 students including both programmers and graphic designers. In the first implementation, we had one project which was including only content production. [4] This time we tried to find project topics which would force the students to do game programming as well. During the first implementation we found that some of the project groups had to work with technologies which were not introduced in the first period. This caused

some challenges but, on the other hand, all the groups were able to achieve results based on customers' specifications by utilizing the support of our game development experts. We were aware that this year we would have again projects in which new technologies have to be applied such as indoor positioning or speech recognition. Thus, an efficient use of our experts in game laboratory was needed again. We also found that all the technologies to be taught are not relevant for all the students studying this course.

3. The Second Implementation

3.1. Working in Project Groups

In the first implementation, students had some challenges in project management. [4] In the current implementation, we utilized Scrum methods. Main part of the students had earlier experiences of Scrum which was used in the third year course called Practice Enterprise. We asked students to work in two week sprints. In practice, the second period was totally lasting nine weeks so the customer projects were divided in four sprints. Students had quite much freedom to arrange their tools so some of the groups were using stickers and white boards and the others were using more sophisticated Scrum software. One of the main challenges students have had when working in projects is to get a flow for their work so that it is lasting from the very beginning of the course until the end. Two week sprints seem quite ideal in this type of projects. This way we are forcing students to meet their customer and present achieved results frequently. Two week sprints give also for teachers a possibility to control students' progress in the project. We have also found that the use of Scrum methods decreases the time used in planning. In the first implementation, students were more or less over-planning their projects. That is to say, we were using the first two weeks of the eight week projects just for planning.

As in [3], game projects are a part of our strategy to get the flow and to change the culture of student's working methods in our specialization area. In other words, students are not any more just coming in for classes and then leave the campus. The idea is to make the campus the hub of the student activities. We have organized for students some space in their schedule to work independently in their projects. The use of game-related topics together with real-life customers has pushed students to work hard and with better motivation than earlier. As reported in [7], we have designed our specialization so that students are working in various projects from the very beginning until their graduation.

3.2. Meeting the Customer

As mentioned above, the students were asked to work in two-week sprints which would require them to communicate in two-week cycles with their customers. Students were asked to arrange all these meetings independently. Teachers or experts from our game laboratory were participating whenever needed. On the other hand, we found our participation slightly challenging because it was difficult to participate without any contribution. Furthermore, in some customer meetings we were forced to interrupt the discussion if the discussion about the objectives was going to the wrong direction. For example, in one of the meetings customers did not have clear picture of the objectives. Students were asked to extend their game concept in a way which was not at all realistic in such a short time left in the project. In this kind of situation, we interrupted the discussion by saying that we will implement the first pilot in the student project and after receiving positive results we will continue this work with other resources (final thesis, RDI projects etc.).

Sometimes customers have expectations which do not fit ideally to our objectives. For example, one of the customers was speculating in the meeting whether we should use visual user interfaces at all. As a result, we saw that some of the students would be in trouble because their expertise area is in graphical design. After our intervention, we were able to find a compromise and all the students had again possibilities to work in the project. In addition, one of the challenges in the customer meetings we have found is an agenda or a lack of understanding how important the agenda is for a successful meeting, especially for teleconference meetings. Sometimes students do not have a clear goal for the meeting, sometimes they are not able to present their results remotely in a form which would help their customers to have an understanding of what the current results are and what the next steps should be.

3.3. Customer Projects

Case: Turku Treasure Hunt
The client, Lingsoft Ltd., aimed for a game in which the player could move from location to another and then complete a variety of location-related tasks and challenges. A demo version of the game consisted of a functioning menu, two locations and the 3D models related to those locations (Figure 1). The whole game was designed to be played on a mobile device, such as tablets and technically powerful mobile phones. The 3D models were made with Blender, an open source 3D modeling software. The game was developed for portable devices, therefore, the models should not be too heavy, as the player should be able to rotate them freely without delay. The finished demo included a functioning menu, the map with the two locations shown, challenges, info and the 3D models. The whole game can be expanded in the future by easily adding any desired locations to the map with their own challenges and 3D models. The speech recognition and GPS may also be implemented later.

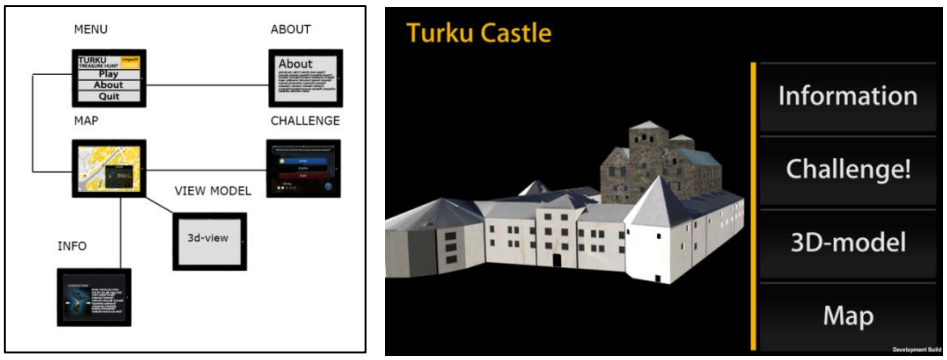

Figure 1. A functionality and a view model screen of the game called Turku Treasure Hunt.

Case: Nagger
Nagger is a prototype of a mobile application for people with concentration problems. The customer in this project was a private person with a clear vision how to support people with a mobile application. In this application, user is able to set up the reminder and be alarmed with recorder voice with the prototype. The user is also able to check statistics from previous tasks and see instructions for using the application. In addition, the user will be rewarded when the task has been done. The usability of the application was our most important requirement to focus upon. Therefore, the application has a clear GUI and is not relying too much on text. As a result, a prototype, which has recording, time interval and statistical features ready, for Android device was developed.

Case: Augmented Reality Game
The purpose of this project was to create an augmented reality game using the Unity and Vuforia frameworks for University of Turku. Members from University of Turku had built a few games using the above mentioned frameworks and wanted to see what kind of idea the project team could build, based on the same technology. In the beginning, the game was supposed to be related to history but eventually the project group were given full freedom on the game plot. In order to create an experience similar to reality, the project group were advised to use image targets from the Vuforia framework. This is a free framework that provides tutorials and sufficient documentation. The demo version of the game was built around the idea that the player wakes up in an abandoned prison and notices that there's no way out (left picture in Figure 2). The player has to figure out a way to escape from the maze, following advice from the game narrator or from the messages that appear on the screen when a target is triggered. After realizing what can be done with the above mentioned technologies, the project group were thinking of the possibility to develop an augmented reality game for the local museum.

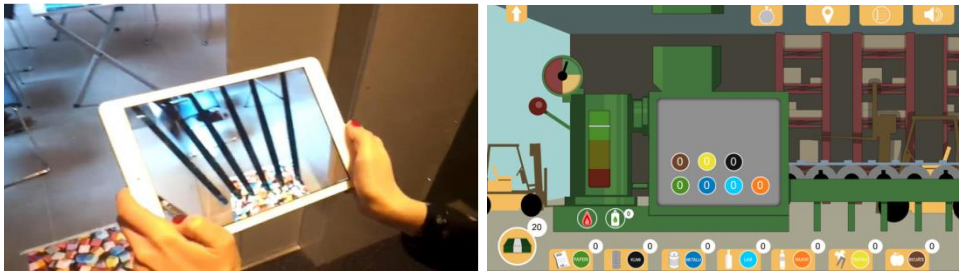
Figure 2. Augmented Reality Game (left) and Recycling Game (right).

Case: Recycling Game
A prototype of a recycling game (right picture Fig.2) was developed to teach and educate people how one's waste can be another's resource. The idea for the game came from the RESU project consortium whose members include our university and companies working in this field. The focus in this game prototype was on gathering resources from different sectors and producing products from the recycling machine. The player has to know what products to produce and keep the financial and environmental in balance. The prototype included different scenes, maps and functionality to demonstrate how the real game would work. As a result, the prototype has four scenes: starting screen, machine and two maps. In starting screen the player can read the game info, start, or quit the game. The machine screen includes the Recycling Machine where the player can make recycled products and bio gas or burn the resources. Burning resources gives energy to keep the Recycling Machine running but it will decrease the ecology meter. Using bio gas, to keep the machine running, increases the ecology me-ter. The player is given tasks to complete to earn money. In the beginning of the game the player is offered with 20 monetary units to buy recycle bins. The player's resources will be gathered after buying trash cans. In the prototype, map screens include village and household views. The player will have to choose the household view from the village map to get to the households in order to buy trashcans to get resources. Other buildings are placeholders in the prototype.

Case: Interactive Art
The main goal of the project called Interactive Art was to develop different applications using Quuppa indoor positioning and various programming platforms. The customer in this case was a private person (a sculpting teacher and artist) and his main interest was to find out how Quuppa technology could be used in different art projects. The customer was especially interested in accuracy and error management of the technology. The project was carried out by using Quuppa technology in conjunction with existing computer programs. The programs used in this project were: Processing.org, PureData and Unity3D. As a result, Processing.org was used to create a visual representation of the data gained from the Quuppa devices. PureData was used for creating sounds based on the data gained from Quuppa. Unity3D was used for developing a game which uses Quuppa technology.

3.4. Case: Build a Solid Wall
The concept of Build a Solid Wall originated from the analogy of the construction of a good paragraph to a well-constructed wall. The idea was to create a serious game where the users would learn principles of good writing by building a solid wall. The original idea was to create solid blocks with strong verbs instead of weak verbs and good construction in terms of syntax, i.e., the word order, and the transition words would be the grout that would bind the wall together. If any of these elements was weak, then the wall would not be solid and, therefore, would in the worst case collapse. In this sense, the game would combine three different disciplines, game technology, English, and Physics.

The project was commissioned by the English teacher of the Faculty who had a dual perspective on the project being an "insider" as a teacher but simultaneously an "outsider" as a customer who is not familiar with the technical aspects of game development. In addition, as an English teacher she naturally paid close attention to how communication and soft skills were deployed throughout the project. The student team comprised of a programmer, a developer and two graphics design students who had recently taken a course in Academic Writing which covered the principles on which the game would be based. The

deliverable outcome of the project would be a game prototype that would be presented in the ICT Showroom 2014.

The following paragraphs describe how the project was run from the customer's point of view. The project lasted eight weeks and it involved five meetings with the customer as shown in Table 1.

Table 1. Meetings with the customer.

Project Week	Type of meeting	Present	Outcome
1	introductory meeting	student team, game technology expert, customer	decision to work on game constructing an abstract
2	status update	student team, customer, course teacher	discussion of the game logic and provision of content by the customer and introduction of a task management application
4	status update	student team, customer	some decisions on the game logic, the blocks of the wall and content provision of the block variants
7	status update	student team, customer	prototype demonstration, improvements to be implemented
8	final meeting	student team, customer	finished prototype review, discussion about the results

From the first meeting, it became clear that the challenge for this project was twofold. The first challenge was the language content because the students would need texts to work with and a natural language is quite challenging to work with in an 8-week project. Therefore, the group would have to work on pre-specified texts that would be an entity of their own to which the principles of good writing would be applied. The idea of the players writing their own text was rejected because it would be time and resource intensive to implement in such a short time. It was agreed that using abstracts would be a more realistic idea to implement. The principles to be practised would still be there. These principles were: the order of the information given by an abstract, in other words, background or problem, purpose, methods, results, and significance; and the choice of more formal and compact sentences. The customer provided language content including variants that the students could work with towards a prototype.

The second challenge was the game logic. This was challenging for both the students and the customers because the students understood what the game logic is and they were talking about rules and/or if statements but the customer did not have experience with game development and struggled to understand what this concept meant in terms of working with the abstract and what she could do to contribute to the progress of the project. Another challenge in terms of game logic was how the wall would be built because the text would be written on the building blocks. The paradox here was that when we write text, it appears on the top of the page and a wall is constructed from its foundations. This was something that it had not occurred to the customer, let alone that it would generate so much discussion. Such discussions dominated the meetings in weeks 2 and 4.

In week 7, part of a prototype was presented and the issues were that there were too many words to sort and choose from in order to form the first row of building blocks that a player would become frustrated with the game and that the text on the blocks could be in more contrast with the background. Suggestions for improvement were made and these also generated a lot of discussion among the students.

In week 8, the finished version of a prototype was presented and reviewed. The group managed to create a prototype with all the basic functionality and necessary graphical content implemented. The developed prototype demonstrates how the game works and looks attractive and has smooth transitions and good usability. Many ideas were left on the table, because they were too difficult to implement, would have

taken too long, or conflicted with the functionality in some way. At the end of this week, the project concluded with the ICT ShowRoom, where the prototype was demonstrated. The group received varying feedback from different people on various aspects of the game.

Lessons to be learnt
There are mainly 4 lessons to be learnt from this case study:

1. Meetings with the customer should be carefully organised. The first meeting was awkward because the three parties met in the customer's office and no-one was speaking because each party was waiting for each other to start. The customer had been informed that she would meet her group. In addition, there was the game development expert who informed that he was there as an observer after the client wondered what his role was there. The students were expecting the other parties to start probably because the customer was a teacher the students knew and expected her to lead the discussion which is what eventually happened. The lesson from here is each part should be briefed about the role in the first meeting and a first meeting protocol should be established.
2. Records of the meeting should record concrete action points and decisions which should be promptly distributed to the involved parties The efficiency and time management of the subsequent meetings could have been improved by sending a brief agenda prior to the meeting followed by a memo of decisions and actions to be taken after the meeting.
3. The meetings should have a clear focus and stay on track. The meetings involved extended discussions on issues of secondary importance to the customer or that the customer could not evaluate before seeing them, for example, the colour and the material of the building blocks was important to the students whereas the customer was more interested in what skills the player would practise, word order or better choice of words. The meetings would drag on for 90 minutes and the customer had to end to those meeting. Some time management guidelines would be useful to implement.
4. Using a task management tool such as Redbooth is very efficient as it creates a communication platform. For example, the client could upload documents, follow the discussions of the group and contact directly each student if necessary.

Interpersonal communication and seeing things from the customer's point of view are typically very much overlooked in this kind of projects. People tend to focus more on the technical competences. In the first implementation reported in [4], we utilized our learning competences (including innovation, curriculum specific and field-specific competences) in the course assessment. That is to say, we utilized self and peer assessment, which gave us outputs such as interest, motivation, contribution, completion of tasks, reports and presentations. In addition, we also used teacher, expert and customer assessments based on our learning competences.

4. Results

4.1. Quality Assurance

As described in Table 2, the customer projects we had in the second implementation had different characteristics. Three projects had in the very beginning special technical requirements: Augmented reality technologies was needed in Augmented Reality Game project, Quuppa indoor positioning and PureData visual programming language for audio generation were needed in Interactive Art project. In addition, Turku Treasure Hunt had in its early phase requirements including speech recognition (which was dropped out later based on the customer's choice). All these technologies had not been introduced to the students during the first period. Therefore, the use of game laboratory experts was needed to ensure that student groups were able to utilize new technologies in their projects.

We can also conclude from Table 2 that only five projects were applying Unity game engine. In Nagger project, the focus was on mobile application with relatively simple user interface. Therefore, it was understandable that the Eclipse software development tool was chosen instead of the Unity game engine. In the Interactive Art project, we had some challenges with the objectives in this project because

originally the visual user interface was not needed. So we were forced to generate another sub-project so that Unity was used just for demonstration purposes and for those students who were more focusing on graphical design. All the other projects were in balance between programming and graphical design. Students were able to receive valuable support from our game experts not only in programming but also in graphical design. For example, in the Turku Treasure Hunt project, a model of Turku castle was provided by the City of Turku. It was then introduced to the project group by our 3D graphical designer who has the latest knowhow of point clouds and 3D models. A couple of our customers wanted to use teleconference (especially Skype) in customer meetings. As already described earlier, the unclear goal of the meeting together with telepresence caused some challenges in communication between the project group and the customer. Especially in these cases, the teacher was forced to interrupt the discussion and give a contribution which was not planned in the meeting agenda.

Table 2. Characteristics of the current customer projects.

Project Name	Special Techs	Unity Game Engine	Programming	Graphics	Teleconf	Clear Focus	Pilot	Product	RDI Project
Build A Solid Wall		X	X	X			X		
Augmented Reality Game	X	X	X	X			X		X
Interactive Art	X	X	X		X		X		
Nagger			X	X		X		X	
Recycling Game		X	X	X			X		X
Turku Treasure Hunt		X	X	X	X	X	X		

These characteristics show that we have been able to provide for the students design-build experiences based on CDIO Standard 5 [6]. That is to say, the students have worked in projects which are requiring co-curricular opportunities for design-build experiences in our game laboratory. Furthermore, we have provided the students with a workspace which supports and encourages hands-on learning as stated in CDIO Standard 6. The students' workspace in our game laboratory has been equipped with the game development tools and technologies for new innovations. Our game laboratory is a student-centered and interactive innovation environment which offers the students opportunities to work closely with our game experts who have the latest knowhow of tools and technologies.

4.2. Presenting Results

At the end of the Digital Media 2 course, the students were asked to present their results in a seminar and in an annual event called ICT Showroom. In the seminar, the students presented their project (including a vision, activities in sprints, and achieved results), and their preparations for the upcoming event (including poster and a strategy). This seminar gave the students the opportunity to check whether everything was ready for the ICT Showroom. It was interesting to see that three of the groups did not have anything to demonstrate in the seminar. That is to say, they took a risk that in one week they would have a demonstration ready and without extra support from our game laboratory to polish the demonstration as much as possible.

Just one week later the course culminated to the ICT Showroom event (Fig 3). ICT ShowRoom is an event which is a student project exhibition and competition open to all students of the joint campus. This event has become an established and integral part of the academic year gathering students, staff and industrial representatives together [8]. It seemed to be difficult for the students to give an elevator pitch for visitors. That is to say some of the student groups had challenges to illustrate what are the innovation elements in their project. This was in line with their final report which showed that some of the student groups were not aware of the-state-of-the-art.

Figure 3. Student groups demonstrating their results in ICT Showroom.

5. Conclusion

In this paper, we have demonstrated that our Digital Media 2 course provides our students with design-build experiences requiring co-curricular opportunities in our game laboratory with the latest technologies in close cooperation with our game development experts. This is in line with CDIO Standard 5 and 6. We have also shown that game development projects are requiring skills from art and technology. This presents some challenges in the course arrangement and therefore this cannot be compared directly to traditional engineering education.

We have seen that students are now more motivated when they are working in game projects and our working culture in our specialization area has developed during these first two implementations to the right direction. The use of rapid development and Scrum methods seems to help students to get a flow. Every two weeks they will be required to meet their client and review together their achievements. Sometimes our customers have unrealistic expectations or our students do not have capabilities to steer the discussion ideally. In these cases, we as teachers have to interrupt and contribute in the discussion with a customer. As a summary, we found challenges especially in interpersonal communication and seeing things from the customer's perspective. These competences are typically very much overlooked in this kind of projects. People tend to focus more on the technical competences. On the other hand, the use of our learning competences (including innovation, curriculum specific and field-specific competences) gives us some tools to tackle these challenges.

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