Team Structure in the Development of Game-Based Learning Environments

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ABSTRACT

This paper examines the factors related to the composition of a development team of digital Game-Based Learning Environments. The aim is to examine the structure of a development team and the expertise, roles and tasks of team members. This study is part of the research project Human-Centered Design of Game-Based Learning Environments. The overall aim of the project is to construct a multidisciplinary and user-driven process for the development of digital Game-Based Learning Environments. The study was conducted according to the principles of development research and action research. The action research cycles consisted of four game development projects. It was discovered that varied expertise in different disciplines was needed in different phases of development. Guidelines for team structure of Game-Based Learning Environments development were presented in the results. Further research is needed on the development process of Game-Based Learning Environments to enable better collaboration of a multi-disciplinary development team.

Author Keywords

Game-Based Learning Environments, serious games, game development, teams

INTRODUCTION

"If you know something well, you can become a digital game-based learning creator." [23]

The above quote, from Marc Prensky's Digital Game-Based Learning, shows great optimism. However, in order to develop the emerging Game-Based Learning Environments discipline we need to research of the development process of Game-Based Learning Environments more thoroughly and form guidelines for quality development process of Game-Based Learning Environments. This study explores the people needed to build a Game-Based Learning Environment and the optimal team structure for that group of people to collaborate on a development project of Game-Based Learning Environments.

The development of motivating and inspiring digital learning games is a complex and multifaceted task. At its best, the quality development of learning games is a multi-disciplinary and user-driven process, which thoroughly combines the expertise of fields such as educational sciences, software engineering, user-centered design, game design and development, and the content disciplines of a specific game [12]. Earlier research on game-based learning has located several elements that indicate the possibilities of digital Game-Based Learning Environments [6, 9, 11, 16]. Earlier research has focused on defining the essential features of digital learning game as an end product [2, 16, 27, 29], the involvement of users in the design process [21], design of collaboration and authoring of collaborative scripts for game environments [9]. However, the process of digital learning game development has not yet been explored so thoroughly.

This paper examines the factors related to the composition of a digital learning game development team. The aim is to examine the structure of a development team and the expertise, roles and tasks of team members. The methods and guidelines utilized in the entertainment game development are useful to some extent. For example, gameplay goals are similar in development of both entertainment and educational games [2, 25].

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TEAM COMPOSITION IN THE DEVELOPMENT OF DIGITAL LEARNING GAMES

The composition of a development team has not been widely examined in the earlier research on game-based learning environments. However, there are several principles in other related areas, especially in the development research and design of learning environments, which can be applied for composing a multifaceted game development team.

Design of game-based learning environments is a conjunction of game development, design of learning environments or learning interventions and software engineering disciplines. In addition to these, the involvement of the future users is essential in order to develop a product that meets the users' actual needs by being engaging, educationally effective, and viable in real contexts [20]. Development projects of Game-Based Learning Environments are usually of a small scale. All the learning game projects examined in this study had teams with less than ten people.

The role of teams in the design of instructional technology

Development research approach focuses on the research-based design of an intervention or a product, such as a game-based learning environment, as a solution for a need to improve learning [31]. As a digital learning game is a software product the goal is also to make this software product fulfill the software requirements. At its best the design process of quality and engaging game-based learning environments combines expertise and know-how of various disciplines and perspectives.

Hedberg and Sims [8] argue that during last decades there have been different ideas about the expertise needed in instructional design. These ideas have been based, at least partly, on the technological developments. In the 1990s the focus shifted to the establishments of teams as integral components of development activities. According to Hedberd and Sims [8] this was a result of emergent set of skill in terms of understanding technology. The development team should consider various elements: the design of interface, the structure of content, the creation of instructional interactions and the learner. McCandliss et al. [19] emphasize the need for continued cross-disciplinary discussions in order to construct shared meaning across different contexts and disciplines. From a social view, design is a collaborative activity in order to achieve consensus about perspectives and actions that might be taken to solve the design problem. According to Hedberg and Sims [8] the involvement of all members of the development team in all phases of the production decreases the likelihood of a technology-pedagogy mismatch.

In addition to the collaboration between diverse disciplines, a crucial assumption in the development research is that interaction with practitioners (i.e. teachers, policy makers, developers etc.) is essential for collaborative construction of workable intervention or prototypes. The involvement of practitioners is necessary both for social reasons (e.g commitment and ownership of users) and for technical benefits, which means improvement of prototypes in real life contexts. The educational and learning expertise needed in the design of digital game-based learning environments can be presumed to include sound knowledge on learning theories and pedagogical design of quality learning environment and also content area expertise in the case of content-specific games.

Teams in software engineering projects

Traditionally, the most productive option for team organization in software engineering projects is that individuals are assigned into permanent teams to which individual functional tasks are then assigned [24]. The project is administered by a project manager. In addition to that individual teams can have team leaders (Fig. 1).

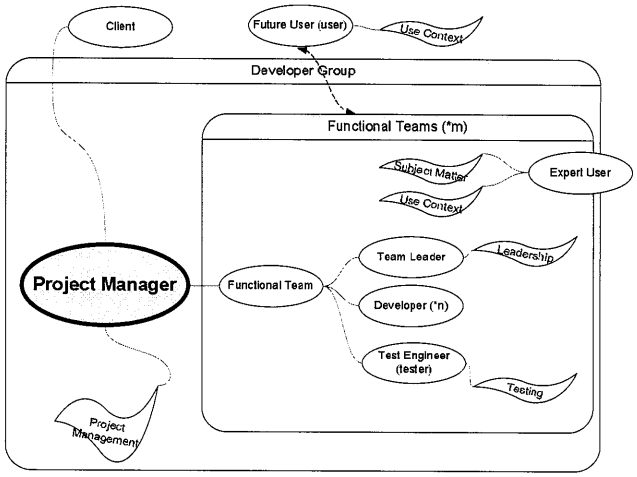

Figure 1: The Team structure of a software development project.

In a software engineering project, every person has expertise on some area of software development. The idea of functional teams is that each team has expertise on the different tasks relating to producing the functionality needed for the end product. Team leaders also need expertise on team management and leadership. The project manager, obviously, needs expertise on project management and planning.

Functional teams consist of developers, who are responsible for the functional portion of the project outcome that has been assigned to their team. Some teams may include test engineers, who are responsible for reviewing and validating the software product in different points of development.

Software development also has other stakeholders than the development group. They can provide the developers important expertise and insight on the project's context and

outcome. These can include the client, future users, possible subject matter experts and expert users. Client is the person who pays for the development of the software product. His main responsibility is to set the goals of the project with the project manager. The client's main responsibility in this task is to be available for discussion and ready to impart all the facts needed for the goal negotiation [24]. The future users of the software product are used by the developers to set the requirements for the product and get insight on the context the software product is to be used in [24]. The users can also review the outcomes (that is, test) of the project [1]. In some cases the development group can recruit a special user to be a part of the development group, to act as an expert on the subject matter the software deals in and to contribute on requirements and testing. This kind of user is called expert user [1].

Teams in entertainment game development projects

In entertainment game development the producer is responsible for the whole project. He/she guarantees that the game is released on schedule and on budget and that everyone involved is doing what they are supposed to [22]. The rest of the development people are arranged into teams according to their responsibility area [25]. There are teams for design, art, programming, audio and testing and quality assurance (Fig. 2).

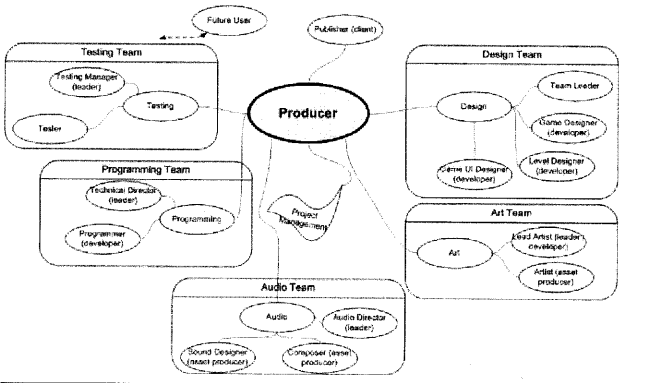

Figure 2: Team structure in entertainment game development.

The design team consists of game designers. Sometimes also a story writer can be added. The art and audio teams consist of graphics and audio producers. The programming team consists of developers of the game software. The testing and QA team consists mostly of gameplay and usability testers. The teams can have team leaders of similar responsibility to software team leaders. The most notable difference between the team structures in entertainment game development and software engineering is that instead of a client, the game development team usually has a client-type relationship with a publisher. The publisher provides funding for the project, markets the game and sells it to suppliers after it has been completed. [22]

Approaches that involve players (users) early the process have not been largely adopted in game design although in the development of productivity software user-centred approaches are widely used and their benefits commonly recognized. Players are generally included in the game design process as testers, and the field of player-centred game design is only just emerging. [5, 28, 30]

The expertise in game development can be described as all the know-how needed to develop a quality game. It can be broken up along the lines of the functional team categorization to game design, game asset production (such as game graphics and story production) and game development. Game design is the process of defining the rules according to which the game works. Game design consists of imagining the game idea, defining the action in the game, describing the game elements and their behavior and communicating the aforementioned to the game developers [25].

The importance of gameplay design expertise is well-documented in the literature: Game-Based Learning Environments should be challenging, engage users with activity and offer a good gameplay experience [2, 27, 29]. The interface of the game is important: it should adhere to usability standards and provide feedback to the player [2, 29]. It is noted that although high end graphics are not essential and Game-Based Learning Environments need not rival entertainment games in production value, the graphic design and good graphics are important for the gameplay experience of a learning game [2, 27].

Teams in user-centered design and users as participants

When examining the structures of development teams from the perspective of user-centered design, multidisciplinary expertise can be identified as one crucial factor. User-centered design requires expertise from different fields [10]. The configuration of the design team depends on the context and goal of the application to be developed; in addition to technical experts and human-computer interaction specialists, there may be a particular need for experts from e.g. education or art [14].

Usability specialists are in a significant role in user-centered projects; they are needed to guide the design process from interaction design point of view. Gulliksen et al. [7] point out that a common problem is that user interface and interaction design questions are not necessarily seen as issues requiring solutions that are the result of explicit, professional activities. Instead, user interface design is often something that is done "on the side" of other development activities and its importance is not acknowledged. Hence, the usability specialists participating in a project need to have the authority to decide on usability-related questions [7].

Crucially, one of the most important expert groups are the users. Their domain of expertise is the experience they have with their own work and problems related to it; in other

words, the users themselves know best how their tools and working conditions can be improved [26]. In learning game design, there are two important user groups representing different expertise: teachers for whom the product should be a useful working tool, and children for whom it should be an engaging learning tool.

In human-computer interaction, the terminology for involving users in development projects is varying. The term user involvement, for example, encompasses a large variety of different approaches and there seems to be no clear consensus as to how the roles of users should be defined. In the field of children and technology, Druin [3] has categorized children's different roles in the design of technology into user, tester, informant, and design partner, but even in this classification there is some confusion in the research literature about their definitions. Therefore, in this article, instead of labeling the role of users into any of the aforementioned categories, the general term "participant" is used, and it is explained separately in relation to each project examined in this article what it concretely entails in each case.

METHOD

This study is part of the research project Human-Centered Design of Game-Based Learning Environments. The overall aim of the project is to construct a multidisciplinary and user-driven process for the development of digital learning games. The design process is explored through the development of several game prototypes. This study addresses three research tasks: 1) team composition of a digital learning game development project, 2) diverse roles of team members, and 3) the structure of the development team in different phases of the project.

This study was conducted according to the principles of development research [31] and action research. The study focused on the learning game development process. The development process is the sum of all actions, events, resources and external conditions involved in a creation of a product (in this case, a Game-Based Learning Environment). The literature review provided a working theory for a game design team structure, and team member roles and tasks. Different development projects were consequent cycles in the study and the developments and experiences in their implementation formed the results of the study. After the projects the working theory was modified according to the findings of the case project. The action research cycles consisted of four game design projects.

The general role of the researcher was that of an active participator, but it varied in the projects. On three of the case projects (Gameli 1.0, Social Responsibility Game and Peatland Adventure) the researcher was a consultant and one representative of the project's client. On one project (Gameli 2.0), the role of the researcher was one of the producers.

Data collection and analysis

The data was gathered through observation, interviews, and project documentation. The case studies were observed during the diverse development phases. Observations were recorded in Research diaries. The participants were interviewed both individually and in groups after the development projects. The individual interviews consisted of open themed questions. In the group interview sessions historical mapping technique was utilized to construct a shared map of the project situation, events and issues during the project and changes that occurred in the project [see 17].

The project documentation consisted of project plans and reports (e.g. phase plans and reports, weekly project diaries). The project documentation was examined for statements about expertise needed, expertise missing from the project, the composition of project team and the roles of different stakeholders. The plans and design documents that the projects produced were examined for indications of impact of the team structure and composition on the projects' outcome. The project review reports to which several stakeholders of the project contributed were examined for statements on the teams expertise and roles and the impact of those in the project. The development teams of the projects were also interviewed about these matters.

The Development Projects

The study consisted of three action research cycles, each of which included one or two game development projects ranging from four months to one year in duration. The participants were the persons involved in the project teams. The game development projects were: Gameli 1.0, Gameli 2.0, Social Responsibility Game (simultaneously with Gameli 2.0), and Peatland Adventure Game.

The aim of the Gameli 1.0 project was to develop an engaging learning game based on the GameWorld modeling and simulation software developed by Centre of Information Technology for Education of the University of Hong Kong [see 18]. The project took place in spring 2005. The research purpose of this project was to explore the traditional software engineering project team structure.

The aim of the Gameli 2.0 project was to expand on the earlier Gameli 1.0 prototype and to produce a simulation game design environment for use in natural science education. The project was realized during November 2005 - March 2006. The research aim of the project was to explore the impact of adding the responsibility of learning and game development experts compared to that of a subject matter expert's in traditional software engineering projects.

The aim of the Gameetta project was to produce a game design document for a game that would communicate the social responsibility aspects of Agora Game Lab's partner organization. The project was conducted during November 2005 - March 2006. The research purpose of this project was to further investigate game development and design expertise and game development process and methods

expertise on a learning game development project. The focus of the project was in producing a quality game concept and design for consideration instead of producing a game prototype.

The Peatland Adventure Game Development project was a part of the Virtuaalisuo (Visu, Virtual Mires and Peatland) project, which addresses issues of peatland nature, its uses, and protection. The Peatland Adventure is an Adobe Flash web adventure game wherein the player chooses his or her role as an animal and takes part in the creation of the peatland. The research purpose of this project was to expand on the findings of previous case projects and experiment with a more flexible team structure.

EXPERIENCES FROM THE CASE PROJECTS

The composition of development teams and the experiences in the case projects is discussed here. The team structures and experiences from the development projects are described one by one in the following sections. The team structure descriptions use two main team types to describe the different phases of development: the pre-production and production team. Pre-production team is the team that forms the basic concept of the developed product and the production team is the team that has the task of building that product.

Gameli 1.0 Project

The Gameli 1.0 project had a team structure similar to the software engineering team structure described in section 2.1 (Fig. 4). The main production team consisted of five developers of which each one served as a team leader for a portion of the project. The project management duty was handled by the management team which consisted of the client and the current team leader. The production team had the possibility of consulting three experts that the client provided. The project had a class of sixth-graders, aged 12 to 13, as participants in three different sessions (group interviews and two prototype evaluation sessions) during the course of the project. The developers had expertise on software engineering, project management. One developer had also expertise on game design and graphic design. The development team did not have any learning or content area expertise, but experts on learning and the content area of the learning game were available for consulting.

Game development and graphics design expertise were noted to be key assets for the production team. After the project it was noted that the lack of simulation game mechanics balancing / level design expertise combined with the fact that only one member of the development team had previous game design expertise proved to be a hindrance to the team schedule-wise as level design took more time than was planned.

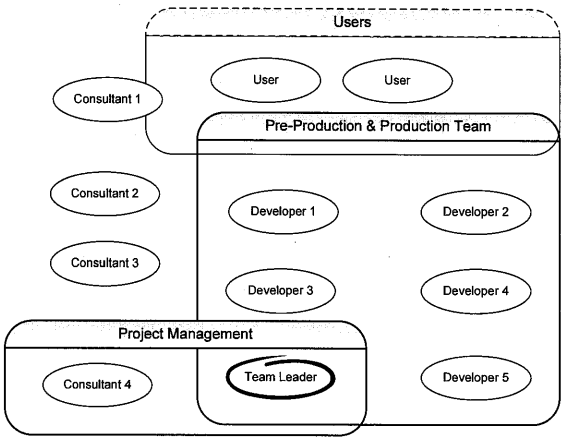

Figure 4: The Team Composition in the Gameli 1.0 Project.

The main issue with this project was the availability and usage of the learning and content area expertise. The development team felt that they could not peruse the learning and content area experts enough and in the project review report the aforementioned experts were not happy on their role either.

As regards the involvement of users in the process, the role division within the development team was rather clear-cut: specific team members had the principal responsibility of planning, carrying out and analyzing the outcomes of the activities conducted with the users. The team considered it a problem, however, that they did not have much prior experience of working with children, and felt that they would have benefited of more training about these issues earlier in the project. Moreover, the involvement of users in the process was seen by the development team as a challenge requiring them to pay especially careful attention to scheduling and time resources, and consequently forcing the project process to become more dynamic.

Gameli 2.0 Project

The Gameli 2.0 project's team structure (Fig. 5) differed from the structure of Gameli 1.0 team in the roles that two of the consultants from the earlier project took the roles of producers in the project. They had an active role in the pre-production and production. Otherwise the development team structure was similar; the only other difference was the availability of teachers as another group of design participants.

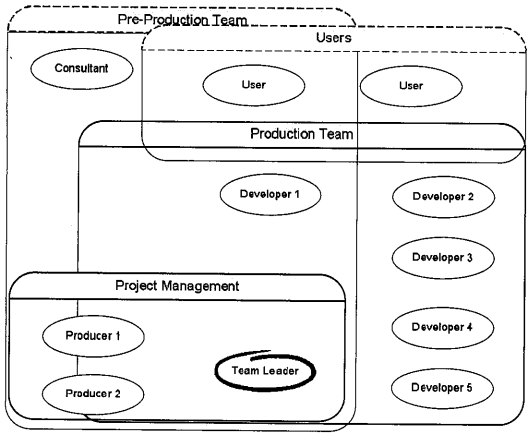

Figure 5: The Team Composition in the Gameli 2.0 Project.

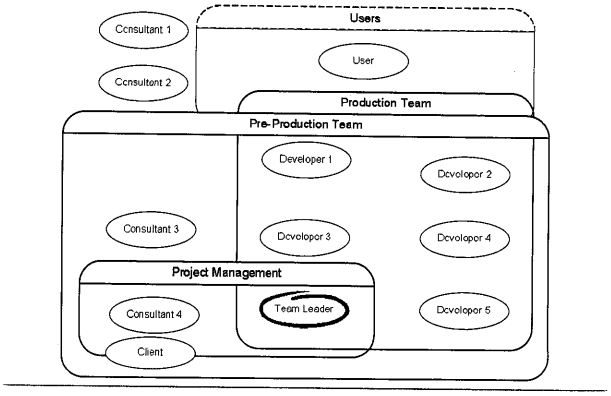

Figure 6: The Team Composition in the Social Responsibility Game Project.

The Gameli 2.0 production team had expertise on software engineering. One member of the group also had expertise on graphic design. The development team's expertise was broadened by the expertise of the producers, who had expertise on learning, game design & development and software engineering. The producers also had more experience in this project as they had already participated in a similar project.

The developers noted that the expertise on learning and insights about the use context of the application from the future end users were crucial for the development, especially at the pre-production phase. Graphics design expertise was also deemed important for the project.

The Gameli 2.0 production team did not have as much game design expertise as Gameli 1.0 project. However, the project was more focused on developing the game playing / creation environment further and improving its usability in the classroom, and therefore – as commented by the developers in the group interview – the lack of this kind of expertise was not a problem.

Social Responsibility Game project

The team structure of the Social Responsibility game (Fig. 6) was similar to that of Gameli 1.0 project. The focus of the project being in the production of a game design, the tasks of pre-production and production teams were different than in other projects, namely game concept generation and game design generation, respectively. The development team gathered a group of users from the target audience of the game to evaluate and provide feedback on their game concepts.

The pre-production team which outlined the game concept consisted of the production team, the client from research group's partner organization and consultants from the research group. The production team had only introductory experience on game development & design, but they had a lot of experience on digital games. The beginning of the project was spent on getting a better understanding of game design with the supervision of the game development consultant. Two developers had graphic design expertise. None of the developers had experience on the content area, but the client was available to provide their expertise on those matters during pre-production.

The potential problem in the Social Responsibility game expertise-wise was the lack of game design and development expertise. The view of the team members was that the tutoring on game development methods was crucial to the success of the project, but more experience inside the production team on the methods and process of game design & development would have resulted in a better use of project resources and therefore a more polished game design.

The Peatland Adventure project

The team of The Peatland Adventure game was structured in a different way to explore a possibility of a more flexible team composition (Fig. 7). The pre-production team consisted of only two developers and a manager with a role that could be considered to be between a manager and a client in terms of responsibility. This means that the managerial responsibilities of the project were divided between the development team and the manager. At the production stage a third developer was added into the team. However, the role of the third developer was more on the technological side. At still a later stage a graphic designer was added to the project. The project team also had access to two consultants and a user participant group consisting of pupils of a primary school.

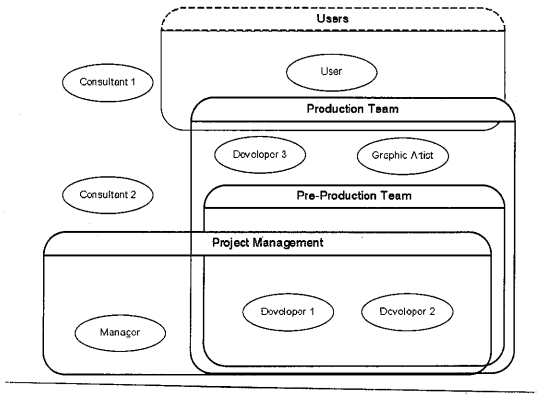

Figure 7: The Team Composition in the Peatland Adventure Game Project.

The two original developers had expertise on learning, content area, game design and software engineering. One of them also had experience on past learning game development projects (Gameli 1.0 & 2.0). The third developer had past experience on learning game projects as well as software engineering and game design expertise.

Before the project, ideas for the game had been gathered with upper secondary and elementary school students, and these ideas were drawn upon in the project. Students of the same school levels also evaluated the prototype of the game.

The project had the expertise it needed and the project management was able to add more experts into the project when needed. Against this background it is not unexpected that neither the developers nor the review report had much to criticize the project in terms of expertise and roles. Although in the beginning of the project the views of the learning / content area expert and the game design expert differed a lot, the small development team structure and the early stage of development enabled them to exchange views and form a common concept to work on. Even as the learning / content area expert's role in the project became smaller in the course of the development, this was reported not to be a problem as the other original developer became a champion of the original shared concept and was able to communicate it to the rest of the team.

GUIDELINES FOR TEAMS IN DEVELOPMENT OF GAME-BASED LEARNING ENVIRONMENTS

In this section, guidelines for team structure and composition in learning game development projects are formed based on the experiences from the case projects.

Traditional Software Engineering Team Structure and Roles

Three case projects, Gameli 1.0, Gameli 2.0 and The Social Responsibility Game projects explored some aspects of the traditional software engineering team structure. It was discovered that the way of using consultants for the expertise needed on other areas than software engineering (that is, learning, game design/ development and the content area of the game) was not optimal in the projects.

Game design and game development process expertise was seen, as the literature on the subject suggests [2, 25, 27] as a crucial factor to the learning game development projects and its presence on both management and development level was seen beneficial to the projects. Of the game asset production expertise the graphics design expertise was deemed the most important. Experiences from the Peatland Adventure project would suggest that the graphics design expert does not have to be in a responsible or active role in the beginning of the project, but can instead be added to the production team later in the project.

With learning and content area experts it was noted that a more responsible and direct approach was needed. In Gameli 1.0 project it was noted that a consultant's role for these experts was not sufficient. A step was taken in Gameli 2.0 project to increase in the responsibilities of learning and content area experts to that of producers. This produced good feedback. Similar experiences resulted from the experimentation of a more flexible team structure in the Peatland Adventure Game project. From the positive experiences on the Peatland Adventure Game project it can be said that the active and responsible role of these experts is important especially in the pre-production team.

In addition to these issues, skills and experience of working with users and sound understanding of user involvement methods manifest as important issues in learning game design. As indicated e.g. by the comments of the development teams and findings from other projects [21], especially the lack of experience of working with children can present challenges for the development process.

Development Team Structure

In the light of the literature analysis provided earlier and the project experiences the following is proposed for the general structure of a learning game development team (Fig. 8).

The development team consists of management, pre-production, production and design partner teams. Management team has a project manager and representation from the other teams. Pre-production team consists of developers that have expertise on learning, game's content area, game design and software engineering. The production team consists of the core group of pre-production team and additional asset producers and developers as needed. At least the experts of game design and software engineering from the pre-production team should be included in the production team also. The design partner team consists of a producer that has expertise on working with users and is responsible for arranging the user participation in the project and the future users of the project.

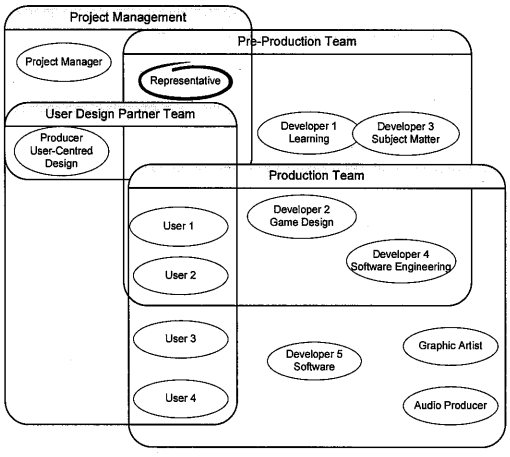

Figure 8: General Team Structure for Game-Based Learning Environments Development Projects.

The inclusion of the design partner team is important especially at the pre-production stage of the project as evidenced in the experiences from both the Gameli 2.0 and Peatland Adventure projects. The team should also stay active during the later stages of the development as feedback on the product is important for the quality of the end product.

CONCLUSION

This study used four case projects of digital learning game development to examine the optimal structure and composition of development teams for learning game development. It was hypothesized that a traditional software engineering team structure enhanced with consultants with expertise on learning, content area and game design and development would be suitable for learning game development.

Results indicated this hypothesis as insufficient. It was discovered that varied expertise in different disciplines was needed in different phases of development. For example, the expertise of learning and content area should be more introduced in the pre-production. The expertise of game design was deemed crucial in both the pre-production and production teams. It was also discovered that the responsibility of those experts should be more prominent than that of consultants. It was also noted that close interaction between the developers is crucial especially during the pre-production stage of the project in order form distributed cognition about the goals of the project and a common ground for implementation of the end product.

Learning game development process must be further studied from the viewpoints of important tasks in the process and methods that enable better collaboration between people of different expertise and background. Part of this research work is further research and refinement the team structure guidelines presented in this article.

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