Learner Collaboration in Digital Game Making: An Emerging Trend

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Abstract
Twenty-First Century skills like creativity, problem solving and collaboration are acknowledged as fundamental in the technology-driven knowledge society. Increasingly, education is being called on to support the development of such skills from the earliest years. This paper examines a promising methodology for this purpose, Learners' Digital Game Building (LDGB) and more specifically the design and construction of digital games by learners working together in collaboration. Advocates of Game-Based Learning (GBL) have long espoused its wide-scale adoption as a pillar of modern, learner-centred education. LDGB takes this a step further: when students design and make games rather than just play them, they invest themselves holistically in the learning process. The authors believe that setting LDGB within an explicitly collaborative framework will not only enhance educational affordances, but will also prove an effective way to nurture learners' capacity to collaborate fruitfully, which itself is a key Twenty-First Century Skill. The paper discusses the theoretical basis for LDGB and describes its actuation in a European research project called MAGICAL. The project aims to generate tools, resources and teacher know-how for implementing collaborative LDGB activities, and to verify the validity and applicability of the methodology in primary and lower secondary school.

Keywords
Game-Based Learning, Digital Game Building, collaboration, 21st century skills

1. Introduction

In the past decade the push for widespread adoption of Game-Based Learning (GBL) in education has been gaining momentum (Garris, Ahlers & Driskell, 2002; Gee, 2003; Egenfeldt-Nielsen, 2006; Sandford et al, 2006; Van Eck, 2006; Van Eck, 2010; Whitton, 2010). Researchers have increasingly argued that the meaning-making that occurs when people play digital games defines a form of literacy that is better suited to the needs of 21st century learners (Gee, 2003; Squire, 2008; Games, 2008). Twenty-First Century skills (21CS) are considered a crucial part of future learning and curriculum innovation and are seen as something children should adopt from the earliest stages of their school career (e.g. Simanowski, 2009). However, current schooling tends to produce passive consumers of media instead of creative problem solvers, critical thinkers and producers of media. School systems need to introduce innovative learning practices and solutions that support the development of 21st century skills. Research in GBL has begun to look beyond just the playing of games to consider the potential of making games as a better way to address learners' needs (Brennan & Resnick, 2012; Games & Squire, 2008). It has been argued that game making supports development of competencies and transversal skills like creative problem solving, collaboration, digital media literacy and systems thinking, and also has a beneficial effect on engagement in STEM subjects (e.g. Zimmerman, 2007; Clark & Sheridan, 2010). This paper considers the emerging learning-by-making-digital-games (LMDG) approach (Kiili et al., 2012) as a possible future learning method that can prepare students for the challenges of the 21st Century.

2. Learning by making digital games

In recent years LDGB has been gaining increasing attention in the fields of educational research and Technology Enhanced Learning (TEL) (Kafai, 2006; Lim, 2008; Prensky, 2008; Robertson & Howells, 2008; Games, 2008; Vos, Van Der Meijden & Denessen, 2011; Robertson, 2012). As a pedagogical strategy LMDG is theoretically founded on Dewey's learning by doing (Dewey, 1938/1997) and Papert's learning by programming (1980) approaches. The pedagogical idea relies on the assumption that construction of artifacts helps children to reformulate their understanding of the subject and to express their personal ideas and feelings about both the subject and the constructed artefacts (Kafai, 2006). Although the artefacts motivate children a lot, they can be regarded only as by-products of learning. At its best the design and development of artefacts is attained through creative teamwork, which supports reflective thinking, collaboration, problem solving and co-construction of knowledge (Roschelle et al., 2000).

While the amount of scholarly work on serious games and educational games has grown steadily over the last decade (e.g. Gee, 2003; Squire, 2008; Ketamo & Kiili, 2010; de Freitas et al, 2012, Devlin, 2011), a literature review we performed revealed that LMDG-related studies are still uncommon. We reviewed almost thirty research papers in order to investigate what kind of evidence exists about the usefulness of LMDG in terms of 21st century skills.

2.1 Learning by making digital games and 21st century skills

The white paper "Defining 21st century skills" published by The Assessment and Teaching of 21st Century Skills project proposed a KSAVE framework that includes 10 important skills necessary for the 21st century (Binkley et al., 2010). The KSAVE framework classifies these skills in four groups as presented in Table 1. In this paper we use the first three skill groups as lenses to classify the results of previous LMDG research in terms of 21st century skills development. The aim is to evaluate the approach's usefulness and identify existing research gaps.

Ways of Thinking
Creativity and innovation Critical thinking, problem solving, decision making Learning to learn, Metacognition
Ways of Working
Communication Collaboration (teamwork)
Tools for Working
Information literacy ICT literacy
Living in the World
Citizenship – local and global Life and career Personal & social responsibility – including cultural awareness and competence

Table 1. The 21st century skills included in the KSAVE framework

Ways of thinking lens

Creativity. Creative learning environments are those that provide resources for creative thinking together with a balance between structure and freedom, opportunities to engage in authentic tasks, collaborative work and reflection as well as possibilities to work in an emotionally safe environment (Davies et al., 2012). All these properties can be integrated in game design tools and pedagogies. In fact, Robertson and Howells (2008) state that user-generated game content can empower learners by enabling them to express their creativity. They emphasize the need for students to begin by playing around with the authoring environment so that they get a feel of what can be done with it; they can then use the possibilities more creatively when game making activities actually begin.

While very few LDGM studies specifically consider the potential for enhancing students' creative thinking, those that do (Eow et al., 2010a; 2010b; Kangas, 2010) show that creativity can be successfully promoted by designing games. Positive results were particularly apparent when game design was combined with a creation of a safe and supportive atmosphere for dreaming, risk-taking and creativity (Eow et al 2010a; 2010b). Providing different kinds of thinking tools and co-creation possibilities was found to be essential for promoting pupils' creativity (Kangas, 2010). The aforementioned studies mainly relied on data from self-reporting and interviews, which was supported by observation (Eow, et al. 2010a; 2010b; Kangas, 2010) and small-group and whole class discussions (Kangas, 2010). A clear need

exists for developing study methods that systematically provide access to students' creative processes and also for sound methods for analyzing the end products.

Critical thinking, problem-solving and decision making. Pedagogy in game design often utilizes designing-for-others (e.g. Kafai, Ching& Marshall, 1997; Baytak& Land, 2010; Owston et al. 2008). This encourages students to assume alternative perspectives, which may in turn support the development of flexibility in their thinking (Kafai et al., 1997). However, Kafai and colleagues remind us that designing for others does not automatically foster this kind of learning. She noticed that 5th and 6th grade learners had difficulties assessing user needs. On the other hand Robertson (2012) reports how students do follow advice from peer reviewers to improve their games, a practice that is more evident in girls than boys. Furthermore, a small case study by Baytak and Land (2010) revealed that students (n=3) became active participants and problem solvers by designing their own games.

Learning to learn and metacognition. To learn effectively, students need to develop strategies and abilities to manage and reflect on their learning. So far, these aspects have attracted little attention in LDGM research. Vos, van der Mejden and Denessen (2011) demonstrate that LDGM stimulates 5th and 6th graders' use of deeper learning strategies when compared to playing games. Carbonaro et al. (2010) found similar results. In their research fifty high school students studied computer science concepts by programming their own role-play games with Neverwinter Nights and ScriptEase toolkits. The results indicated that the game authoring activity stimulated higher order thinking skills. Furthermore, the results revealed that girls significantly outperformed boys in these skills.

Ways of working lens

Communication. Developing games provides opportunities to develop a range of communication skills related to both to reading and writing and to use of spoken language and visual communication aids. Owston et al. (2008) compared the effect on 4th graders' reading and writing skills when they either developed or played trivia games. They found that the game development group outperformed the player group in logical sentence construction. Furthermore, developing games can enhance students' communications skills by inducing learners to cater for a target audience. For example, Kafai et al. (1997) conducted a study in which 5th and 6th graders made games for younger students. The results showed that the condition of having to use language the younger ones would understand encouraged the students to adopt their own wording instead of just copy-pasting information from external resources.

We argue that developing games has strong potential for developing the literacy skills needed in the knowledge society. LDGM can include traditional and new literacy activities (e.g. Robertson 2012) and utilize easy-to-use tools for composing interactive stories (Carbonaro et al, 2008). For example, in Robertsons' study, vocabulary exercises, individual reading, brainstorming, discussions, story writing and drawing were combined in making computer games. Carbonaro et al. found that high school students can successfully construct sophisticated interactive stories with very little training. Both studies found evidence that girls in particular might benefit from game authoring activities that emphasize narratives writing skills; Robertson found that girls spent more time on writing conversations and utilized peer feedback more eagerly than boys.

Collaboration. A study by Kangas (2010) showed that game playing and computer game creation in a playful learning environment provided young children with opportunities to

practice workgroup skills. Designing games can lead to an enhanced sense of classroom community, which encourages students to ask and provide help (Baytak & Land, 2010) and to share tips and alternative work methods (Robertson & Nicholson, 2007). Denner (2007) found that the majority of girls in an after school game-making program liked the social aspects of the activities. However, Denner did not analyse student collaboration procedures or the impact of collaboration on the game quality. Indeed, in the studies reviewed analysis of collaboration is mainly restricted to peer review and providing feedback.

Tools for working

Information literacy. LDGM projects can include phases in which students search online for information of use in game development, thus providing opportunities to practice information literacies. For example, in study by Owston et al. (2008), 4th graders used the Internet as an information source when they developed questions for their Trivia games. The students also developed a better understanding on the public nature of the Internet as their games were freely accessible online.

ICT literacy. Developing a game is a very complex task and requires several ICT skills. Tools adopted in game-making activities range from software targeted at children to professional tools. Experiences with a range of authoring tools are reported. These include Adventure Author (Robertson, 2012), Gamemaker (Baytak& Land, 2010), Gamestar Mechanic (Torres, 2009), Scratch (Brennan &Resnick, 2012) and Neverwinter Nights (Robertson & Howells, 2008). LMDG activities varied widely and selected tools need to be appropriate for learning objectives and students' skill level. According to Yatim and Masuch (2007), an ideal game-making tool for children would scale in programming 'granularity' in order to grow in capability along with the user's programming skills.

Scratch is a good example of visual programming language designed for children with no previous programming experience. The idea of Scratch derives from Lego bricks; Scratch syntax is based on a set of graphical programming blocks that children can snap together to create programs (Resnick, et al., 2009). In order to lower the starting threshold, the blocks are designed to fit together only in ways that make syntactic sense. According to Brennan and Resnick (2012), such approaches develop students' computational thinking skills. In a similar manner, Denner et al. (2012) showed that when "students with no prior programming experience program a computer game they have the opportunity to practice computational thinking that will prepare them for further studies in computing." Other commonly reported benefits of LMDG activities are systems thinking (Torres, 2009), interactive story authoring (Carbonaro et al., 2008) and storytelling (Robertson, 2012). However, only few studies reported gains in visual design or audience awareness skills (Robertson, 2012).

Robertson and Nicholson (2007) suggested that before beginning LMDG activities, students should play example games made with the same authoring tool they are to use themselves so they grasp the affordances and become more explorative. Furthermore, they suggest that the authoring system should propose hints about unused features and also include idea recording tools.

2.2 Main findings and research gaps

Analysis of papers in the literature review has shown that LMDG research has mainly focused on motivational aspects and adoption issues (e.g. Harnisch, 2010; Robertson & Howell, 2007; Owston, et al., 2008; Kazimoglu, et al., 2012). Very few studies have focused

on development of 21st century skills. Furthermore, the review reveals that most empirical studies conducted have been short-term and involved small sample sizes. Clearly, proponents of game making as a learning method rely heavily on conceptual research and more robust empirical research is needed, especially regarding the social nature of LMDG. One reason for this may be that digital game making tools do not usually feature support for collaborative game making online. Given the different roles (designers, programmers, artists) and skills involved, game making is an eminently collaborative activity. Furthermore, the research field lacks methods to assess learning processes and outcomes in LMDG activities. Only a handful of the studies focus on assessment of 21st century skills (Brennan & Resnick, 2012; Resnick et al., 2009) and this is a shortcoming common in the GBL field generally.

3. MAGICAL project: aims and adopted approach

These gaps are currently being addressed in MAGICAL (Making Games in Collaboration for Learning), a multilateral project co-funded under the European Commission's Lifelong Learning Programme. The project aims to define sound educational methods and pedagogical strategies for implementing collaborative LMDG, with special attention to the impact on 21CS (Dagnino et al., 2012). MAGICAL will contribute empirically gained know-how by deploying the proposed methodology in a set of field experiences carried out in partner countries at primary and lower secondary school level. Learners, including those with special needs, will have the opportunity to engage in collaborative game building using digital tools, and will be guided and supported where appropriate by their teachers, who play a key role in the process. To this end the project addresses three different target populations: student teachers, health professionals and pupils. Children with special needs have been included for the purposes of observing possible specificities in their experience with game building activities.

One of the innovative aspects of MAGICAL is the specific attention devoted to collaboration in game building. This has led to the development of MAGOS, a special gamified authoring environment which has unique features for supporting game making that set it apart from other LMDG tools. In MAGOS the various game authoring roles like designing game levels, defining game physics, creating visuals, sounds and music etc. are distributed among up to four player/authors, who are allocated different fields of responsibility. This hardwires an initial degree of cooperation into the authoring process. In addition, player/authors can exchange their individual “powers” (game mechanics) on the fly as they require, which involves communication, negotiation and (potentially) collaboration. In keeping with the gamified fantasy theme of MAGOS, the powers are presented as sets of magic spells with which the player/authors create their joint game.

To make game design and development accessible to young learners, MAGOS eschews any type of programming in favour of a high-level authoring approach (Ketamo et al, 2012). Games are developed by personalising, selecting and dragging elements (and their attributes) onto a tiled game space and then clicking and setting values. In this way a number of different game types are possible, including platformers, puzzles, racing and role playing/adventure games.

To pave the way for classroom experiences in MAGICAL, student teachers and health professionals in partner countries (Belgium, Finland, Italy, UK) are undergoing specific parallel courses that provide them with a grounding in the theory and practice of GBL and LMDG. A key aspect of this training effort is the design and orchestration of learning activities through carefully thought-out pedagogical plans. A specially designed online tool

called the Pedagogical Planner[1] has been developed for designing LMDG activities and this will also help MAGICAL researchers identify and document best practices. Classroom experiences will be carefully monitored not just to gauge the impact on learning processes but also to identify emergent good practices that can be adopted outside the project confines to support transferability and foster wider uptake of game making in education generally.

In addition to MAGOS and the Pedagogical Planner, MAGICAL is to produce a teachers' support package (example games, "magical" idea generation tool, ready-to-adapt teaching units, teacher's guide, etc.) and a tool kit for developing teacher training actions dedicated to GBL and collaborative game making. One early project output attracting interest in the LMDG and GBL communities is a library of game building environments for learners that are currently available around the world[2]

4. Conclusions

As Twenty-First Century Skills are critical success factors in the knowledge society, research and development of learning solutions that contribute to these skills is crucial. This paper has proposed collaborative learning-by-making-digital-games (LMDG) as one solution to this demand. However, in order for widespread take-up of LMDG to become a reality, several research gaps need to be bridged. As a number of researchers have argued (e.g. Games 2008; Games & Squire 2008; Brennan & Resnick 2012), more empirical studies need to be conducted before the precise added value of LMDG can be quantified. Firstly, evidence-based proof is required to establish whether it is actually an effective and engaging pedagogical strategy that contributes to 21CS. Secondly, methods and models are needed for assessing students' learning processes in LMDG activities. Thirdly, we need to develop pedagogical models that are easy to adopt and adapt for integrating the LMDG approach in teaching practice. Finally, we need well-designed game authoring environments with a proven track record in supporting collaborative LMDG activities so that promising research results and model good practices can be mainstreamed, thus becoming part of daily school practice.

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[1]Beta version currently available here: http://www.magical-project.net/?q=planner

[2] The libraryislocatedathttp://amc.pori.tut.fi/game-building-tools/. It currently catalogues and provides access to over fifty game making tools.

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