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Using game making pedagogy to facilitate student learning of interactive multimedia

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With the growing importance of interactive multimedia in our society, it is increasingly essential to equip students with knowledge of and skills in multimedia production. However, as the traditional lecture based instruction on this emerging subject area is not effective for students in achieving the expected learning outcomes, a seven stage game making pedagogical model (GMP) is proposed for facilitating student learning. Both quantitative and qualitative responses of 25 higher diploma students majoring in information technology to the effectiveness of the GMP model were collected and analysed. Initial findings support that the model helps improve students' learning motivation, problem solving ability and creativity. In addition, a majority of students agreed that using a wiki platform for peer collaboration, as suggested by the model, is particularly conducive to enhancing their knowledge of and skills with interactive multimedia.

Introduction

In recent years, interactive multimedia has extensively permeated into our daily life. It plays a significant role in shaping new forms of communication, advertisement, entertainment and education. For example, there has been a growing recognition of its benefits to different disciplinary areas such as language (Almekhlafi, 2006; Chang & Lehman, 2002), science (Buckley, 2000; Roberts & Zydney, 2004), management (Klassen & Drummond, 2000; Passerini, 2007) and e-learning (Kekkonen-Moneta & Moneta, 2002; Zhang, 2005).

The widespread use of interactive multimedia technologies and applications potentially opens up a huge demand for skilled and qualified talents with the ability to create innovative multimedia products. To satisfy such demand, some universities and colleges around the world have started to offer courses in multimedia design and development. A general objective for these courses is to equip learners with the necessary knowledge, skills and competence to contribute to the multimedia industry. In Hong Kong, the School of Professional and Continuing Education at the University of Hong Kong (HKU SPACE) has launched a range of sub-degree courses teaching interactive multimedia development.

Despite an increasing number of courses in interactive multimedia available for study, it is still unclear how to most effectively facilitate student learning in this emerging subject area. In this paper a pedagogical model, *game making pedagogy* (GMP) is proposed to help fill the gap. Our research findings indicate that the GMP model is effective in helping students to enhance their problem solving skills, learning motivation, and creativity in multimedia.

Background

In response to the *Digital 21 Strategy* enforced by the Hong Kong SAR Government (HKSAR, 2001), the Division of Information Technology in HKU SPACE has offered a three-year Higher Diploma Programme in Information Technology (HDIT), to address the shortage of IT manpower in Hong Kong since 2001. The program aims to give secondary school leavers an all round capability as well as specialised knowledge and skills required for career development and further studies. In the program, a course named *Interactive Multimedia* was designed for offer to final year students. The main objective for this course was enabling students to produce interactive multimedia content, integrating 3D models, graphics, sound, video, animation and user interactivity, for different purposes such as presentation, entertainment and education.

The course was a credit-bearing module lasting 15 weeks and with 3 contact hours a week. Its assessment consisted of both continuous assessment and a final examination. As more emphasis was put on the practical skills, the continuous assessment accounted for 70% of the overall grade while the examination constituted 30% only. To fulfill the requirement of continuous assessment, students were required to complete 10 in-class tutorial exercises and 3 individual, take home assignments.

Based on the evaluation after the first implementation of the course, the course instructors reported that they had found several common learning problems influencing the overall student performance in their classes. The problems included weak problem solving ability, lack of creativity and low learning motivation. Some of the instructors' observations with respect to the identified problems are described below.

Weak problem solving ability

In each class, students were taught the concepts of multimedia technologies in lectures and then a tutorial would follow. The tutorials required students to attempt some hands on exercises by using the multimedia authoring tool *Macromedia Director*. During the lectures, most students seemed to pay attention to the teaching materials. But it turned out that a majority had no idea of how to solve the practical exercises during the tutorials. Students relied very much on the suggested solutions prepared by the instructors.

Lack of creativity

As noted earlier, students were requested to complete 3 individual assignments. One of the assignments asked students to design their own 3D logo and illustrate special effects such as animation, sound and lighting with the logo. However, it was discovered that their products were very similar to some multimedia examples demonstrated in classes. They simply imitated the examples to create their own logos from which their creativity was little exercised.

Low learning motivation

Students' learning motivation was found to be generally low. For example, students tended to give up doing hands on exercises too readily when they had no ideas in their first attempt. Furthermore, some students just aimed at getting a pass in the course, so they were not enthusiastic to enhance the quality of their assignments for getting a

higher grade. Not surprisingly, they also seldom referenced any additional resources given by the instructors.

Literature review

Today's young adults aged 16-24 have grown up in a networked environment in which they get used to interacting with technology and engaging enthusiastically in computer games playing (Mitchell & Savill-Smith, 2004). For this new generation, traditional face to face learning seems less favored than studying in an immersive digital gaming world (Foreman, 2003). The shift of students' preferred learning style stimulates researchers to explore and think about how to make educational use of computer games for improving students' learning (Egenfeldt-Nielsen, 2005).

Tailor-made and well-designed computer games have been known to offer a number of benefits over traditional, lecture based teaching. From the perspective of individualised learning, recent research suggests that educational computer games can raise learners' motivation (Aldrich, 2005; Michael & Chen, 2006; Prensky, 2000), enable learners to engage in interactive learning environments (Amory, 2001; Gee, 2003; Kafai, 2001; Quinn, 2005), intensify their information retention (Hogle, 1996; Randel, Morris, Wetzel & Whitehill, 1992), and improve their problem solving skills (Gros, 2007; Mayer et al., 2002; Squire, 2005). Moreover, some computer games also serve as virtual worlds which cultivate peer groups with social competence to share knowledge, skills and resources, as well as to solve problems in collaborative manner (Gee, 2003; Gros, 2007; Shaffer, Squire, Halverson, & Gee, 2005).

However, it does not guarantee that the use of computer games often brings the said advantages to learners, unless the educational content, the pedagogy and the assessment method are carefully considered to integrate with the games. It is trivial that a computer game with content violating the ethical values in society or distorting the facts may not be appropriate for educational use (Gros, 2007). Even though the game content may be well-selected and organised for being studied, deep learning would probably not happen to the learners if an appropriate pedagogical model does not exist (Kiili, 2007; Salen, 2007). Assuming an effective game pedagogy is already connected closely with the game content, we still need to consider how teachers can assess students' performance and how they can provide prompt feedback to the students (Ma, Williams, Prejean & Richard, 2007).

As most commercial games are created for recreational rather than instructional purposes, many teachers face a big challenge in choosing a suitable game for satisfying all necessary aspects and school curriculum (Green & McNeese, 2007). Rather than resorting to whatever is available from the market, teachers may consider building their own educational games and some design principles to follow. To this end, educational game design has received increasing attention and some models on this topic have been developed (Amory, 2007; Amory & Seagram, 2003; Kiili, 2005; Quinn, 1994). However, the models share the common drawback of relying more on the teachers' effort in the game design and construction and less upon students' involvement in the same process. As a result, students may take a passive role, to accepting the game narratives and playing with it according to a set of goals and rules defined by teachers. Not only does this approach leads to an increase in teachers' workload, it also restricts students from having autonomy to produce and present their own products. The latter runs counter to the finding that students prefer

presenting themselves and their artefacts in a learning environment (Zemsky & Massey, 2004).

In contrast to having educators design games for learners, encouraging learners to create their own games is an alternative way to incorporate games into the learning process (Eck, 2006). As pointed out by Berrenberg and Prosser (1991), game creation by learners can promote their interest, creativity and competence to examine the study materials in a *History of Psychology* course. The game making approach is also believed to be applicable to other courses, specifically for those related to computer programming (Cagiltay, 2007; Minkel, 2002; Salen, 2007). No matter what disciplinary area this approach is applied to, game making is inherently an iterative process in which game producers would be shaped to become more reflective in action (Salen, 2007) and more competent to demonstrate game literacy (Buckingham & Burn, 2007). However, we find that the study of a practical pedagogical model tying with the approach in a learner driven direction is still limited. This paper is intended to fill such a gap for the subject domain of interactive multimedia.

Game making pedagogy for interactive multimedia

In this section, a pedagogical model named *Game Making Pedagogy* (GMP) is proposed to make use of the game making approach for addressing student learning problems in interactive multimedia. The model focuses on the student centred learning process underpinned by the constructivist paradigm. In cognitive constructivism, learners are perceived to construct new knowledge based upon their prior experience and personal interpretation of the world (Piaget, 1971). Individual learners are believed to learn better if they are engaged in knowledge construction by themselves, rather than by passive information reception. This general principle is applied to the GMP model by fostering students' active and independent learning.

As an extension of cognitive constructivism, social constructivism emphasises the collaborative nature of knowledge construction in group learning under socio-cultural contexts (Vygotsky, 1978). This characteristic is in line with learners' learning preference of communicating and interacting with each other (Zemsky & Massey, 2004). Given that collaborative ability is regarded as a necessary skill for jobs (Hamalaninen, 2008) and is recognised as a passport to success in the 21st century (Dondlinger, 2007), the GMP model aims at providing a supporting environment to promote collaboration among students.

In our model, a free wiki system named *MediaWiki* (http://www.mediawiki.org/), originally written for *Wikipedia*, is adopted to offer a collaborative learning environment for students. The decision to use a wiki as a platform for student collaboration is based on a number of its potential benefits. Firstly, a wiki can enable learners to construct collective knowledge (Boulos, Maramba & Wheeler, 2006). Secondly, it can facilitate learners to have deeper engagement and thoughtful consideration (Williams & Jacobs, 2004). Furthermore, it can increase learners' responsibility for their own learning (Bold, 2006) and also enable students to keep track of their work (Watson, Boudreau, York, Greiner & Wynn, 2008). Without the support of appropriate pedagogical guidance, however, the use of a wiki alone may not be effective and successful (Choy & Ng, 2007). Therefore, in our study, the wiki system is associated with the relevant stages of the GMP model to harness its full power for promoting collaborative learning.

The GMP model comprises seven stages: *Topics exploration, Knowledge acquisition, Goal setting, Content creation, Component synthesis, Peer review* and *Assessment*. Each stage is described in the following paragraphs, with Table 1 summarising key points of the model in terms of the main purposes, learning activities and learning tools involved at different stages.

Stage 1: Topics exploration

Initially, the course instructors start with selecting and sharing some representative computer games, which can either be obtained from previous cohorts of students or downloaded from public websites, having relevance to the knowledge and skills covered in the multimedia course. Students are given opportunities to trial the games and find out the strengths and weaknesses. They are also requested to develop a list of criteria for evaluating the games, based on their own expectations as well as their prior gaming experience. Every demonstrated game is an authentic example that motivates students to explore the key topics in interactive multimedia. Additionally, the games can also provide students with insights into common attributes that "good" interactive multimedia products should display.

Stage 2: Knowledge acquisition

In the second stage, students are introduced to the core knowledge and skills of interactive multimedia through lectures. During tutorial sessions, they are then asked to reflect upon some gaming applications of what they have learned in lectures, and they are also challenged to choose and implement one application as a class exercise. This stage is designed to enable students to plan their own series of small goals (the reflection) and to achieve them (the implementation) at their own pace. Not only can it strengthen students' confidence in their class work, but also prepare them to formulate an achievable project goal in the next stage.

Stage 3: Goal setting

Upon completion of stage 2, students are asked to form project groups, numbering 3 to 4 students. Each group has to design and implement a computer game project by using the multimedia knowledge and skills covered in the course. Their completed games will be assessed according to the evaluation criteria previously set in stage 1. A game proposal, outlining the game design followed by feasibility study, implementation schedule and task allocation among group members, is needed to be prepared collaboratively within each group. To make certain that their project goals are attainable, each group will be supported by instructors' scaffolding like explicit directions and guidance (Bereiter & Scardamalia, 1987).

Stage 4: Content creation

Once a game proposal is approved by instructors, the group members proceed to create the game content. Producing multimedia elements, establishing game rules and programming game play are typical jobs in this stage. Student groups are required to break down their jobs into smaller tasks and assign the tasks among themselves. Because most tasks are highly interdependent and a failure in one task might lead to an overall project failure, every member has to keep others well informed on the progress attained, the difficulties encountered and the changes made to the original design. This kind of intra-group communication can be well managed by the wiki system (Xu, 2007).

Table 1: Summary of the seven stages in the GMP model

Stages	Main purposes	Learning activities	Learning tools
1. Topic exploration	• Enhance motivation for learning interactive multimedia in an authentic context • Have an overview of the topics covered in the multimedia course • Connect prior gaming experience with learning interactive multimedia	• Trial computer games given by the instructors • Explore key topics that should be covered in the multimedia course • Determine a set of criteria for evaluating a multimedia game	• Computer games produced by the previous cohorts of students or downloaded from public websites.
2. Knowledge acquisition	• Have an understanding of the core knowledge and skills • Set small goals and achieve them by using what have been learned in lectures as well as prior gaming experience • Strengthen learning confidence in the multimedia course	• Study the core multimedia knowledge and skills • Reflect on the potential applications of what have been learned • Choose and implement one application of what have been learned	• Course materials • Interactive multimedia authoring software (e.g., *Macromedia Director*)
3. Goal setting	• Encourage peer collaboration within the same group • Have the autonomy to determine the project details • Associate the project goal with the evaluation criteria	• Prepare a game proposal collaboratively within a group • Discuss the proposal with the instructors • Revise the proposal according to the instructors' directions and guidance	• Wiki system (e.g., *Media Wiki*)
4. Content creation	• Encourage peer collaboration within the same group • Develop effective communication with group members	• Work on the allocated tasks • Discuss one's progress and problems with other group members • Support other group members to cope with any difficulties encountered in the project	• Wiki system (e.g., *Media Wiki*)
5. Component synthesis	• Foster critical examination of group work in different levels • Develop problem solving strategies and skills • Enhance collaboration ability in a co-authoring environment	• Carry out unit and integration tests for various components in the game • Identify problems and propose solutions to improve the game • Write the game documentation collaboratively within a group	• Wiki system (e.g., *Media Wiki*)
6. Peer review	• Facilitate collaborative learning among different groups • Foster reflection on one's strengths and weaknesses by reviewing others' work	• Trial the games created by other groups • Give feedback on others' work • Reflect on the weaknesses of one's own game • Modify one's own game with consideration of others' feedback	• Computer games produced by different project groups • Wiki system (e.g., *Media Wiki*)

7. Assessment	• Encourage presentation of one's own product • Promote reflection on the efforts of oneself and others.	• Give a presentation on one's own game • Assess the contribution of oneself and others in the same group	• Computer games produced by different project groups

Stage 5: Component synthesis

Game elements are needed to be synthesised, examined and revised repeatedly until a satisfactory game is completed. During this process, unit and integration tests will be carried out by each group to examine the correctness of different components in their game. Problems are likely to be identified at both unit and integration levels. Students can then be exposed to opportunities for developing their independent and collaborative problem solving strategies, that might not otherwise exist in their class exercises. Similarly, students can experience the process of co-writing through preparation of game documentation in the wiki system.

Stage 6: Peer review

Up to this point, the games created from different student groups are ready for preliminary evaluation. All the game executables will be shared with the whole class in the wiki system. Students can freely download and trial the games created by other groups from which they may learn some good ideas to improve their own games. They can also opt to give feedback and comments on the games. Based on the received feedback and comments, students are likely to be more aware of problems in their games so that they can make corresponding changes before presenting their games for the final assessment.

Stage 7: Assessment

The final stage pertains to group assessment carried out by the instructors. Every group is scheduled to present its game in class. Depending on the presentation performance together with the assessment criteria set out in stage 1, such as the multimedia design, the game rules and the game play, a grade will be awarded. Immediately after the presentation, members are asked to assess the efforts of themselves as well as others in the same group. The instructors will determine the individual effort and thus the individual grades on the basis of the peer assessment along with the participation level in wiki, which might result in students receiving different grades within the same group.

As noted in Table 1, the GMP model suggests a set of learning activities with supporting learning tools for students. The activities can gradually help with motivating students to engage with the multimedia course, develop their multimedia knowledge and skills, enable them to apply what they have learned into their games, as well as encourage reflection on the project outputs. Figure 1 illustrates screenshots from three projects under the implementation of the GMP model. In the next section, students' perception of the effectiveness of the model in learning interactive multimedia will be analysed and discussed.

Figure 1: Screenshots from three projects

Research methodology

The main purpose of this research is to investigate students' attitudes toward the effectiveness of GMP model in enhancing their learning motivation, problem solving ability and creativity when studying interactive multimedia. Participants were 25 students (20 males and 5 females) who took a course in interactive multimedia under the Higher Diploma Programme in Information Technology. Their mean age was 21 years old and their mean GPA was 2.8. Before taking the course in interactive

multimedia, the participants had completed an introductory course in multimedia and thus they all had some fundamental knowledge about multimedia.

Research data was collected by both quantitative and qualitative methods after the group presentation. A 20-item questionnaire adapted from the *Instructional Material Motivational Survey* (IMMS) (Keller, 1983), *Social Problem Solving Inventory Revised* (SPSI-R) (D'Zurilla, Nezu & Maydeu-Olivares, 1996) and *Creativity Training Effectiveness Questionnaire* (Birdi, 2005) was administered to the participants. The questions were structured to solicit students' perceptions toward how the GMP model influences their learning motivation, problem solving ability and creativity. Their answers were measured by a five point Likert scale, "Strongly Agree" (SA), "Agree" (A), "Neutral" (N), "Disagree" (D), and "Strongly Disagree" (SD). To ensure the clarity of the questions, a classroom based pilot study was carried out to trial the questionnaire with a group of 30 students randomly selected from 6 IT classes. Comments and results from the group were evaluated and validated to come up with a revised version by 4 IT instructors with expertise in teaching multimedia. The revised questionnaire was used with the participants in this study.

Following the questionnaire session, a semi-structured interview was conducted individually with each participant to collect their views on the learning experience in the course. Specifically, three questions were asked during the interview:

Q1. Have you faced any problems and tackled them by yourself during the computer game development process?
Q2. Have you implemented any creative ideas, which were not taught in classes, into your project?
Q3. Do you think that you have actively engaged in the game project? Why or why not?

The solicited views were explored in order to verify students' questionnaire responses. Furthermore, they are useful to further enhance the GMP model in future.

Results and analysis

Analysis of students' questionnaire responses

This section presents the results obtained from both the questionnaire and interview sessions. Table 2 presents participants' perceptions in 5 different agreement levels (SA, A, N, D, SD) toward the 20 questionnaire items. These were designed to collect participants' perceptions regarding the impact of GMP model in three different aspects. Items 1 to 8 focus on learning motivation, items 9 to 14 pertain to problem solving ability, and items 15 to 20 concern creativity. The Cronbach alpha coefficient was adopted as an index of scale for internal consistency of the three aspects. Under the calculation by SPSS, the coefficients are 0.83, 0.89 and 0.82 for learning motivation, problem solving ability and creativity, respectively. The values suggest that the aspects possess satisfactory internal consistency. For easier data interpretation, the average item percentages of the three aspects are illustrated in Figure 2.

The percentages of students' agreement for the items related to learning motivation vary from 68% to 100%. On average, the percentage of agreement is about 83%. It indicates that a majority of participants were motivated to learn with the GMP model. Among the item responses, 84% of participants stated that it was a pleasure to create

Table 2: Students' perceptions toward their learning motivation, problem solving ability and creativity in interactive multimedia when the GMP model is adopted

Items		% of SA	% of A	% of N	% of D	% of SD
1.	Creating my own multimedia game is an interesting idea	16%	72%	12%	0%	0%
2.	Playing the games made by other students could stimulate my curiosity	40%	52%	8%	0%	0%
3.	I could find the direct relationship between the course content and game making	16%	56%	28%	0%	0%
4.	The course content is relevant to my interests	32%	52%	16%	0%	0%
5.	After playing the games made by other students , the course content seemed not so difficult	12%	56%	24%	8%	0%
6.	I was confident to work on my game project	8%	64%	28%	0%	0%
7.	It was a pleasure to work on my game project	36%	48%	16%	0%	0%
8.	Successful completion of my own game made me feel satisfied	44%	56%	0%	0%	0%
9.	I always thought about the problems encountered in my game project	20%	44%	24%	12%	0%
10.	I felt that solving a problem in my game project was challenging	32%	40%	20%	8%	0%
11.	I considered different solutions for the same problem in my game project	16%	40%	32%	12%	0%
12.	I used a systematic method to find out the best solution in my game project	8%	44%	32%	16%	0%
13.	I tried to solve my project problems even though the first attempt failed	40%	32%	20%	8%	0%
14.	I seldom acted on the first idea that came to my mind in my game project	8%	48%	32%	12%	0%
15.	I learned how to come up with more varied solutions to my game project	4%	48%	40%	8%	0%
16.	I was keen to put my ideas into practice in my game project	28%	44%	20%	8%	0%
17.	I had many ideas to improve the quality of my game project outputs	8%	44%	36%	12%	0%
18.	I made changes to the way my group had worked	8%	16%	28%	36%	12%
19.	I was encouraged to carry out my game project in fresh ways	20%	52%	24%	4%	0%
20.	My group members always shared different views to look at the same project problems	8%	56%	32%	4%	0%

their own games, and 72% rated that they could find a direct relationship between the course content and game making. Furthermore, all participants agreed that successful completion of their own games made them feel satisfied. From the cognitive constructivist point of view, the figures support the proposition that game making is a motivating and relevant context in which participants are likely to construct their knowledge and skills of interactive multimedia.

Game making is also a good approach for facilitating problem solving. Figure 2 shows that an average of 62% of participants agreed the questionnaire items regarding the problem solving ability. Most participants (72%) felt that solving problems in the game project was challenging. This may probably lead to participants' positive attitude and behaviour towards problem solving. For example, 72% of participants responded that they did not give up solving the project problems even if their first attempts were unsuccessful. More importantly, over half of participants (56%) dealt with a problem

by considering multiple solutions, and some (52%) pointed out that a systematic method was used to find out the best solution. On the whole, the problem solving ability is likely to be activated by the game making approach.

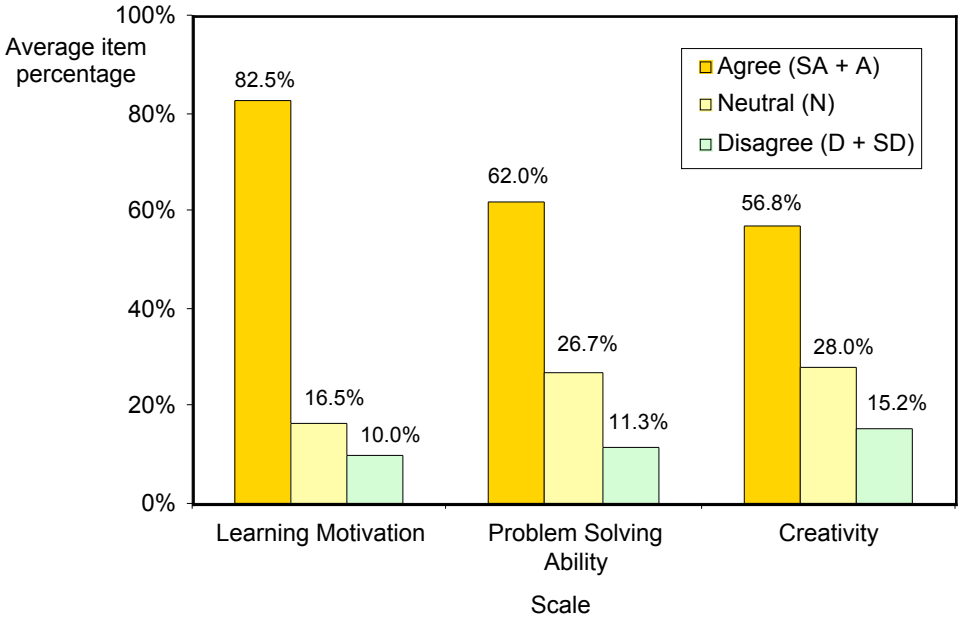

Figure 2: Average item percentages of learning motivation, problem solving ability and creativity

Like the previous two aspects, most items in relation to creativity were agreed by a great proportion of participants. For example, about 72% of participants reported that they were encouraged to work in fresh ways and the same high percentage showed enthusiasm to implement their own ideas in the project. Additionally, 64% of participants responded that their group members always shared different views to look at the same project problems, which may result in a stimulus to the creativity on a group basis that corresponds to the conception of social constructivism.

Analysis of students' feedback in the interview

Sometimes, when it is unlikely to separate a phenomenon from its context, qualitative approaches may be used for investigation (Yin, 1994). We argue that analysing the effectiveness of our proposed model should also be examined by a qualitative approach. To collect the qualitative data, a semi-structured interview was conducted with each participant. In this section, we will discuss the participants' qualitative answers in response to the questions (Q1 to Q3) centred on the themes of problem solving, creativity and motivation.

For Q1, participants were asked to identify the problems they encountered in the game development process. Most of them (84%) mentioned that game logic programming was the most difficult problem because it had to handle the association between different multimedia elements and their corresponding interactivity with players. For

dealing with the problems, most participants (80%) noticed that finding examples in reference books and online discussion forums was useful. One participant responded:

> At the beginning, we intended to implement a 3D photo hunt game which requires players to point out the differences between two rotating 3D objects. However, many technical problems related to the game logic arose during the development. The problems included how to count the time and score, how to get the exact positions clicked on the 3D objects by the players, how to determine whether the players are won and etc. In the end, we created our game by extending some similar examples from reference books as well as game related discussion forums on the Internet.

Similarly, here is one more response regarding the game logic programming:

> A practical problem we faced was about the game audio. As multiple sound effects were designed to occur simultaneously in our shooting game, how to generate different audios, synchronize them and toggle among them in varying situations had to be considered. The issues were addressed by looking at similar examples from the Wikipedia, reference books and also game development websites.

Participants' responses to Q1 revealed that they were active in solving the problems they faced during their game project implementation. In addition to seeking internal assistance from teachers and peers, they also relied on external assistance like related reference books, discussion forum and websites, to search for appropriate solutions. The findings are in line with the goal of promoting participants' positive attitude and behavior towards problem solving, through attempting a challenging and worthwhile activity.

For Q2, participants were asked to share some creative ideas implemented into their game project, which were not taught in class. Rather than constructing a completely novel idea, a high proportion of participants (68%) indicated that they had selected an existing game as a basis and then they had turned it into a new one. This strategy was less sophisticated but effective, as identified by a participant's feedback:

> Our instructor demonstrated a Tic-Tae-Toe game in the first lesson. I thought that it is a fun and simple game with which my group can start. We tried to redesign the game to make it more stereoscopic, challenging and exciting for players. Our idea was to transform the original tic tae toe from a 3x3 board game to a 3x3x3 cubic game. Instead of placing 3D noughts or crosses into spaces, players can alternatively shoot some cubes to turn them around until noughts or crosses were surfaced in a horizontal, vertical or diagonal row. I am happy that my classmates enjoyed this innovative game play.

Below is a feedback from another participant working in the same way but with an emphasis that an "extraordinary" game rule can renew a traditional game:

> A traditional game of hammering nails was demonstrated in class. We thought that we could reverse its game rules to turn it into a new game. What we considered was to make the nails weightless so that they can fly. After conducting technical feasibility study by our group members, a library called Havok Xtras was found in *Director* and it could probably help. We then discussed and built a game prototype based on the library to see if it really worked. Fortunately, it worked well and we decided our proposal title as creating a game of hammering flying nails.

On the other hand, some participants (24%) believed that creative ideas could be constructed by considering different combinations of specific knowledge and skills for a gaming context. One of the participants shared that:

> Our instructor briefly introduced an advanced topic of particle system in class. He demonstrated several natural phenomena made of particles, such as water, fire, smoke, explosion and etc. While many classmates thought that particle system could only be used to display cosmetic effects, we believed that particles could be combined with user interactivity to create an exciting game. Therefore, our members studied different examples of how to interact with particles from the Internet and then came up with a proposal for implementing a fire fighting game. The game depended on controlling the movement of water particles and their collisions.

Specifically, the feedback to Q2 supports the importance of the course exploration stage for facilitating participants' creativity. Through the demonstration of and interaction with others' games, participants were enabled to gain an understanding of what a multimedia game should contain, and they were also stimulated to propose new game ideas. From the feedback, on the other hand, it is also noted that collaboration among group members was deemed critical and helpful for refining the game ideas and making them more feasible.

For Q3, participants were asked to reflect on whether and why they had actively engaged in the game project. By and large, they spent at least 5 hours a week on making their own games. Some of them (56%) explained that they had a strong sense of autonomy and ownership over their project outputs. For example, a participant expressed that:

> We spent a lot of time on the game project because we found it very interesting and challenging than other traditional projects. The game project provided great flexibility for us to design and implement our own ideas into a multimedia game. The sense of autonomy and ownership pushed us to spend more time on the project, and to make our own game more entertaining and funny.

Some participants (48%) indicated that the project provided them a good opportunity to directly connect the knowledge and skills of interactive multimedia to their gaming experience directly. One of the participants said that:

> Almost all my classmates, including my group members and me, used to play computer games for at least 30 minutes every day. We become more or less familiar with of game rules, interfaces, controls as well as interactions in different types of games. The project was a good practice for us to apply what we have learned into our most familiar and interested area.

Moreover, over a half emphasised that intra-group sharing and inter-group review were good for pushing the project forward, particularly in a wiki platform. A participant's view is shown below:

> I thought that I was engaged in the game project because of the support given by classmates in the same group and other groups. They were open and active to discuss ideas, problems and project progress. In particular, I enjoyed surfing in the wiki system from which I could find many useful information and resources shared by my classmates. I could hardly experience the same culture of sharing in other courses.

From the participants' responses to Q3, we can identify several reasons why participants enjoyed engaging in making their own games. Providing participants with a sense of autonomy and ownership to design their own products is likely to be a critical factor. In addition, the project should maintain a high degree of relatedness to

individual experience as well as social context. Both characteristics are supported by the GMP model.

Conclusions

In this paper a model, namely *Game Making Pedagogy* (GMP) is proposed to facilitate student learning of interactive multimedia. In brief, the model focuses on student a centred learning process and it is underpinned by the constructivist paradigm. It is a seven stage model in which students are provided with opportunities to design, develop, and review their own computer games in groups. In the model, students are also encouraged to become active learners and to take the responsibility for their own learning, while instructors act as facilitators to provide appropriate guidance and direction to the students.

Initial findings of this study support that the GMP model facilitates students' learning motivation, problem solving ability, and creativity in an interactive multimedia course. In particular, the findings indicate that students were satisfied with making their own multimedia games. The high level of satisfaction and the strong sense of ownership motivate individual students to participate in an active learning process throughout the course. Furthermore, the findings also point out that students valued the intra-group and inter-group interactions (like peer review) from which they believed that they could benefit. Overall, both individual and social dimensions of constructivism are considered in the model.

A limitation of this study is the small sample size of respondents that might influence the representativeness of the findings. Therefore, future research will be carried out to collect more participants' responses for analysis. Based on a larger number of responses, our proposed learning activities can be further refined to fit students' different learning styles. Furthermore, we also consider extending the game making pedagogical model for facilitating learning in ohter disciplines besides interactive multimedia.

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