Article 6

Embedding Gamification Elements in Distributed Pair Programming (DPP): A Conceptual Framework

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Abstract
This paper discusses a conceptual model of a web system for distributed pair programming (DPP) that involves the use of gamification elements as the new feature of the system. DPP is one of the efforts that support pair programming over geographically distributed environment. Pairs from dispersed locations can communicate with each other to code or completing tasks via the Internet. The proposed model involved the development of a web system that facilitates DPP with the use of web-based applications and web 2.0 tools. Nevertheless, in order to make the web system more fun and interactive, gamification elements are embedded in the proposed model. Suitable game mechanics based on gamification Octalysis Framework are selected that focused on the development and achievement of each pair in the DPP web system. The aim of the proposed model is not only to encourage the use of the gamified DPP web system but also to improve learners' experiences in learning programming that is stress free and more interactive.

Keywords: *programming, distributed pair programming, gamification*

Introduction

Pair programming has been widely implemented in the field of education with the aim to improve the quality of codes, boost the confidence of the students and making the process of learning more enjoyable (He & Chen, 2014).

Further discussion done by Nurzaid and Zulfikri (2015) has showed that pair programming can be a successful tool when implemented in programming classes. Among the positive impacts are students happened to be less frustrated with the outcomes from the pair programming sessions, becomes more trustworthy and developed more confident in their friendship. He and Chen (2014) also added that the creative process to produce many meaningful and quality codes had increased together with students' interests in learning programming with their partners.
Nonetheless, pair programming is mainly implemented in physical classrooms or computer laboratories where the interactions are visible and can be closely monitored by the lecturers. In the team effectiveness model proposed by Faja (2013) then discussed by Nurzaid and Zulfikri (2015), pair programming can also be employed in a virtual environment and it is called distributed pair programming (DPP). To implement DPP, it requires different academic settings and design, such as providing network access to the teams and lecturers from dispersed locations.

Furthermore, in order to make learning using DPP more enjoyable and engaging, gamification elements can be embedded into the features of the system. For instance, a study done by Li et al. (2013), has shown that gamifications when included in an e-learning platform, would encourage

students to be more engaged and interested in the subject matter. In the study, they have used the PeerSpace, a collaborative learning environment with the support of Web 2.0 tools that promote student interactions on course-related topics as well as purely social matters. Among the gamification elements included in their system are the participation points, a level system based on participation points, a progress bar, leader boards, collaborative programming for community building and casual games (Li et al., 2013).

Therefore, the purpose of this paper is to discuss the proposed of a conceptual framework that describes the integration of gamification elements in a DPP environment. The aim is to provide a model or guideline of the development of a gamified e-learning system that supports DPP learning processes.

Background of Study

i. Pair Programming

Pair programming can be described as an agile software development technique that involves two programmers who are sitting on the same workstation and working on a same task together (Maguire et al., 2014). The task may involve designing and coding the same algorithm where each person plays important role as the "driver" or "navigator" (Faja, 2013). During the pair programming session, the programmer who acts as the "driver" is taking charge on the mouse and keyboard while the other person who acts as the "navigator" observes the "driver" and offers suggestions and corrections to the algorithm or the codes (Faja, 2013; Li et al., 2013) . The roles as "driver" and "navigator" are interchangeable where each partner will be given chances to alternate their roles after certain period of time while collaborating in designing, coding and reviewing (Faja, 2013; Maguire et al., 2014). This technique is normally used to enhance software productivity at a higher level of software quality (Winkler et al., 2013).

ii. Team Effectiveness Model of Pair Programming

Team effectiveness model is to describe the main factors that will influence the success of the pair programming. The success of pair programming is contributed by the four factors in the team effectiveness model that has been discussed in recent study conducted by Faja (2013) as shown in Figure 1.

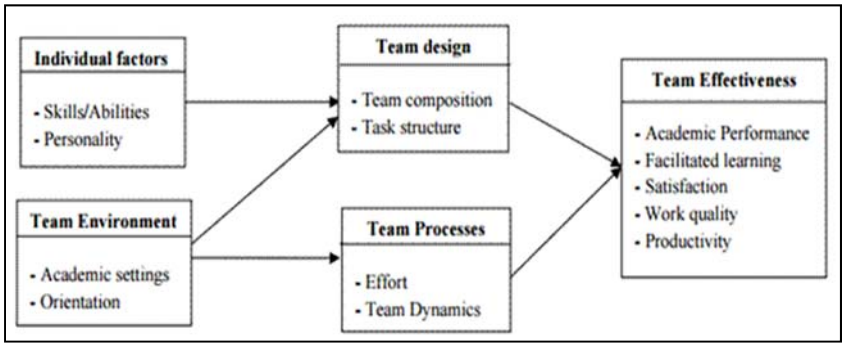

Figure 1: Team effectiveness model of pair programming

The first factor, which is the individual factor emphasizing on the importance of finding the right partner or pair based on the skills, abilities or personality (Faja, 2013). For instance, Chen and He

(2014) claimed that for better performance, pairs should be assigned randomly, with disparity of academic performance. Other study suggested that matching pairs, with the same skill levels or academic performance would likely perform better and produce quality codes in a shorter amount of time (Zacharis, 2011), while some claimed that slight difference in pairs' skill levels will worked it best in pair programming (Kellaris & Backstrom, 2015).

The second factor is the team environment that emphasizes on the academic setting and orientation. The academic setting proposed in this model provides two different mechanisms, which are either practical session in traditional classrooms or implementation of pair programming in a virtual environment (Faja, 2011). While most of the previous studies focused on face-to-face interaction, other researchers have developed web applications to support the pair programming practice, especially in supporting distance learning. For instance, a web-based system named Online Collaborative Learning System (OCLS) has been developed to support pair collaboration and discussion for learning programming in a virtual environment. Although, the technique used in the study did not clearly mentioned the pair programming concept, however, the "Think-Pair-Share" technique embedded in the system has also reflected the adoption of pair programming approach (Mahfudzah, et al., 2013).

The third influential factor is the team design and task structure. The design of the team structure and task complexity has significant role in pair programming approach. Pair programming implementation involved set of rules and setting such as it needs to be implemented in a control in-class environment with only one workstation for each pair. Nonetheless, pair programming also can be implemented for outside assignments although this approach seemed to be difficult to control as students often found it difficult to collaborate due to conflicting schedules (Faja, 2011).

The final factor in the team effectiveness model is the team processes that involved team dynamics and effort. As mentioned by Braught and Wahls (2011), in ensuring positive pair interactions and efforts, lecturers or instructors must also be actively engaged in the whole pair programming process. Switching roles between pairs has been suggested as one of the key elements that determine the dynamic of the pair. Having one person to constantly check the codes is another way to maintain the team dynamics and foster teamwork and communication skills (Kellaris & Backstrom, 2015).

iii. Distributed Pair Programming(DPP)

Pair programming is typically done as collocated activity with both programmers sharing control of a single physical computer, keyboard and mouse. Distributed pair programming (DPP) brings pair programming to the geographically distributed environment where collocated collaboration is not feasible. Furthermore, DPP is supported by technologies such as screen and desktop sharing as well as collaborative editors over the internet. In desktop sharing, all users, not only share a single screen, but also have simultaneous keyboard and mouse access (McKinsey, 2015). Teaching and learning can be more interesting and more efficient by using DPP instead of pair programming in the same location. As an example, the student and another student in the same group might be in the different locations, but can still connect with each other to complete the given tasks and formed their own virtual team. In general, a virtual team can be defined as a group of people who

work together towards a common goal but operate across time, distance, culture and organizational boundaries (Bernado, 2012).

iv. Gamification in education

Gamification can be defined as the use of game mechanics in the non-game context such as in the field of education, health, financial and many others (Deterding et al., 2011). The aim of integrating gamification elements in learning is usually to contribute motivation principles and engagement based on the gaming concept into ordinary activities (Nah et al. 2013). Gamification in education can be seen as an alternative way to use game dynamics and game mechanics in the scope of learning with the aim to motivate students to become more engaged in the process of learning and interacting with other students (Lee et al, 2011).

v. Gamifications in e-Learning

Developing and deploying effective e-learning programs can give many advantages in teaching and learning process. According to Nagarajan et al. (2010), one of the advantages in using e-learning is that it is more cost effective where it promotes paperless environment, no delays, no physical classrooms are needed and does not involve travel expenses. It also enables tutor and learner to take what they have just learned from their computer screens and apply it to the task at hand (Nagarajan et al., 2010).

Gamification in e-learning platforms also can make the process of learning and teaching becomes more interactive and effective. According to Deterding et al., (2011), gamification, however, offers a whole new set of opportunities to make the students more involved, such as clear goals with variety of ways to approach them, curiosity, and systems of challenges, constraints and achievements.

Meanwhile, gamification also offers the concept of accomplishment, which refers to an impressive thing that is done or achieved after a lot of work. Students can earn badges by completing certain tasks, solving certain exercise first, attaining certain levels in specific amount of time, achieving success in challenges, contest and being active on the forum (Swacha et al., 2013). By doing this, students can feel that challenges in study are more important and powerful and can trigger them to emphasize their learning.

Proposed of Conceptual Framework of the Gamified Distributed Pair Programming (DPP)

As depicted in Figure 2, the proposed conceptual model consists of combinations of few different elements. The first element is the pair programming technique that was adapted from the team effectiveness model discussed by Faja (2013). As the development of DPP is aimed to cater pairs that located in different locations, therefore lecturers need to consider the individual factors to form the pairings. In this case, we proposed the difference between students' programming skills as the pairing motive. The idea was to encourage the low achievers to learn and perform better when partnered with their high achiever friends.

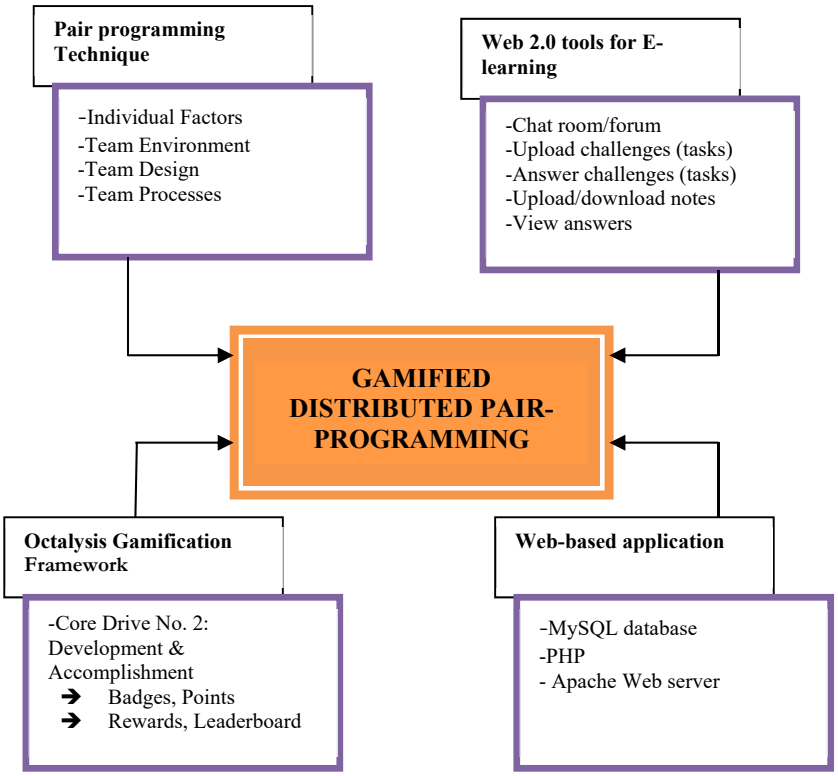

Figure 2: A conceptual model of gamified distributed pair-programming

The next factor is pivotal, which involves academic setting an orientation. Since DPP is a pair programming implemented in a virtual environment, the orientation of the pairs depends on their identifications or tags to ensure the role as driver and navigator can be interchangeable. For this purpose, we proposed the use of gamification elements in the system such as avatar or emoji to identify the virtual teams. Meanwhile, to ensure the effectiveness of DPP or virtual pair programming, the development of the online system involved the web-based application tools such as the MySQL database, PHP and Apache web server.

The third factor according to the team effectiveness model is the team design that includes the construction of tasks. In this model, the selected topics for the tasks were taken from the introductory programming course and the questions constructed were based on the six levels of the Bloom's Taxonomy cognitive domains comprising of Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. The objective is to encourage the students or pairs to answer questions from the easiest level, which is Knowledge and progressing until they reach the hardest level, which is Evaluation.

The final factor involves the team processes. The development of this system must ensure to retain the dynamics of the pairs and interactions between students and lecturers. We proposed the use of Web 2.0 tools to support teams' communication and collaboration. Meanwhile, to ensure the interactivity and fun learning while answering the programming questions, gamification elements were also proposed to be embedded in the system's assessment modules.

The gamification elements selected for this system consist of suitable game mechanics and game dynamics that support DPP functionalities as well acting as catalyst to improve learners' engagements. In order to select the suitable gamification elements for this project, the Octalysis Framework developed by Chao (2015) was referred. This gamification framework consists of eight core drives, which are Development and Accomplishment, Epic Meaning and Calling, Empowerment of Creativity and Feedback, Social Influence and Relatedness, Unpredictability and Curiosity, Loss and Avoidance, Scarcity and Impatience and Ownership and Possession. Each of the core drive has different meanings and aims. For instance, if the system focusing on Development and Accomplishment, few game mechanics are proposed to use such as points, rewards, progress bar, ranking, leader board, step-by-step tutorial and many others Chao (2015).

Other core drives involved the use of narrative, elitism, humanity hero for Epic Meaning and Calling, social invitations, social treasures, group quest and mentorship for Social Influence and Relatedness and the use of visual storytelling, mini quests and random rewards for Unpredictability and Curiosity. Meanwhile, the gamified system can also focus on using the core drive Loss and Avoidance by using game mechanics such as sunk-cost tragedy, progress loss and scarlet letter or using countdown, throttles, patient feedback, appointment dynamics for Scarcity and Impatience and finally using virtual goods, built from scratch, avatar, collection sets, recruitment and monitoring for Ownership and Possession (Chao, 2015). Any gamified systems can have one or combinations of these core drives and can be applied in either the assessment module, social interactions or tasks.

For the purpose of this project, we proposed only one core drive based on the Octalysis Framework, which is the Development and Accomplishment". This core drive focuses on using game mechanics such as badges, points, rewards and leader board and often relates to learning progression, practicing, competition, collaboration, tutoring, and eventually overcoming challenges (Chao, 2015). The word "challenge" here means giving something such as badge or trophy or appreciation in order to make the challenges becomes more meaningful (Chao, 2015).

Based on the proposed conceptual model, we had developed the DPP web system. Via the system, the pairs were given set of tasks by the lecturers. The tasks needed to be completed within teams consist of different levels of difficulties as mentioned in the previous section. Each pair needed to unlock each level of question and were given points, rewards and badges for all correct answers. Finally, at the end of each session of the online tasks, the leader board displayed the ranks of the teams based on the points collected by each pair. This concept will encourage the team to collaborate, compete with each other and score in each task.

Conclusion

In conclusion, the proposed conceptual model of gamified distributed pair programming (DPP) is seen as an effort to support the practices of distributed pair programming where coders or students can discuss and collaborate to produce better codes over the Internet. Moreover, in order to make the learning process and experience more enjoyable, the gamification elements were integrated into the web system. Among the game mechanics proposed embedded into the system are badges, extra points and giving out rewards to the pairs that successfully completed the given tasks and

produce error-free codes. It is expected that by introducing the game mechanics in the learning process, students or programmers will become dynamic coders and more confident in producing better codes, thus helping them to improve their performances in programming courses as well.

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