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Improving teamwork skills and enhancing deep learning via development of board game using cooperative learning method in Reaction Engineering course

M.T. Azizan[a,b,*], N. Mellon[b], R.M. Ramli[b], S. Yusup[b]

[a] Center for Excellence in Teaching and Learning (CETaL), Universiti Teknologi PETRONAS, Seri Iskandar, 32610 Perak, Malaysia

[b] Chemical Engineering Department, Universiti Teknologi PETRONAS, Seri Iskandar, 32610 Perak, Malaysia

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ABSTRACT

To produce well-rounded students with excellent teamwork skills and creativity, one of the teaching strategies that can be adopted in engineering education is cooperative learning. This study aims to enhance creativity, deep learning and improve teamwork skills among the third-year chemical engineering students using cooperative learning strategy. Complex instruction method is adopted by instructing the students to develop a board game and embed technical based questions, which are related to kinetic and reactor design subject (KRD) and other two courses, as part of the integrated project. The reflections from the students, the findings from the survey and the evaluation of the students' outputs, suggested that though they enjoyed the activity, it was a challenging and a complex task, which in turn provoked their thoughts, creativity and made them acquired teamwork skills.

1. Introduction

In the world that we are currently living now, it is extremely crucial for the educators, especially the engineering educators to produce graduates that can solve problems and face the grand challenges in this 21st century. A university is the final gate to nurture the students in a formal education prior to entering the real working environment. As such, there are many essential skills, which need to be developed in the students at the higher institution. These skills are being outlined by 21st century learning design developed by UNESCO (Breivik, 2005), which encompasses collaborative skill, critical thinking, connectivity and creativity.

Despite these challenges, many of the faculty members in engineering faculties worldwide were hired based on their research capabilities, but not on their ability to teach and their pedagogical background. As a result, traditional teaching style (chalk and talk) is a norm everywhere, especially in engineering education (Mills and Treagust, 2003). To produce the 21st centuries graduates as what we aspired, there is a major need to reform the way how the students are being taught in the classroom, moving away from teacher-centered to student-centered learning (Ministry of Education Malaysia, 2015).

In Malaysia, the launched of Malaysian Higher Education Blueprint 2015–2025 (MHEB) had further emphasized

* *Corresponding author at*: Center for Excellence in Teaching and Learning (CETaL), Universiti Teknologi PETRONAS, Seri Iskandar, 32610 Perak, Malaysia.
E-mail address: tazliazizan@utp.edu.my (M.T. Azizan).

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the need to employ a student-centered learning approach at higher institutions (Ministry of Education Malaysia, 2015). Out of ten shifts that are highlighted, shift 1 of MHEB (Holistic, Entrepreneurial and Balanced Graduate) clearly mentions the need to promote critical thinking skills and entrepreneurial mindset among the graduates, which shifts away the role of a graduate from a job seeker to a job creator.

One of the student-centered learning strategies that could make an impact to the students is cooperative learning. Cooperative learning was introduced approximately 40 years ago as part of pedagogy techniques in the classroom (Sharan, 1980). The aim of cooperative learning is to promote effective learning in and outside of the class, via group activities. Each member works closely with each other to achieve the same objectives. Cooperative learning is able to instill teamwork values (Sharan, 1980) of which it has been introduced as an instructional method for small groups, consisted of 4–5 members, so they will work together to maximize their own and each other's learning (Felder and Brent, 2007).

Cooperative learning is claimed to reduce the occurrence of undesired atmosphere in a group work such as having free riders that will claim equal mark with others who persevere (Smith et al., 2005). Many world-renowned engineering education specialists had recommended the incorporation of cooperative learning in the engineering based teaching and learning activities as it has been proven to promote the effectiveness in learning at higher education (Johnson and Johnson, 1999). Another reason why cooperative learning is needed at higher education institutions is further supported by a study, which suggested that the students who dropped out of college are mainly for two reasons: failure to establish a social network of friends and classmates, and failure to become academically involved in the class (Johnson and Johnson, 1999). The researches on cooperative learning that were carried out in the United States colleges found that the impact of cooperative learning can be classified into four aspects: (i) Academic Success, (ii) Quality of Relationships, (iii) Psychological Adjustment and (iv) Positive Attitude toward College Experience (Johnson and Johnson, 1999).

Cooperative learning can be adopted formally or informally (Mills and Treagust, 2003). The introduction of active learning in the classroom, for example, is an informal cooperative learning strategy. The students will work in pair for few minutes after 10–15 min of lecture to achieve a joint temporary goal, as assigned by the lecturer in the class. In one lecture hour, an informal cooperative learning session can be introduced up to 4 times, with each session last for up to 4 min (Smith et al., 2005)

A formal cooperative learning is a more structured activity, in comparison to the active learning (Sharan, 1980). Five essential elements that must be embedded in a structured cooperative learning are: positive interdependence, face to face promotive interaction, individual accountability, teamwork skills and group processing (Felder and Brent, 2007). These elements shall promote the group to become a high performing cooperative learning group, and they effectively learn.

Complex instruction is a method in cooperative learning developed by Cohen and Lotan (1995) at Stanford University. The aim of complex instruction is to promote fairness and equality for a diverse classroom, in ensuring the students are successful academically by working together in a group, given a specific role for each team member. The students are expected to have a thorough planning and organization to ensure successful outcomes. The instructor in addition, is required to allow the students to experience and understand the concept by assigning open ended problems that need to be solved. A heterogeneous group must be formed so that the students will learn from each other and ultimately complete the assigned task (Cohen and Lotan, 1995). The students need to define their own role in the project to ensure equity and any dispute or disagreement is minimized.

Despite cooperative learning has been introduced few decades ago, the uptake of this approach following the right principles of cooperative learning in engineering education in the Asian region is still lagged behind. A teacher-centered approach is always preferable, and very few intensive research works have been reported with regards to the student-centered learning, such as cooperative learning (Thanh et al., 2008) and problem-based learning (Yusof et al., 2005; Salleh et al., 2007). In addition, in preparing the students toward 21st century education, the technology has not been fully utilized for enhanced learning experience to spark the creativity of these engineering students. The use of websites as group portfolio and video to replace the typical presentation method are yet to be discovered.

On top of these, game based learning had become the trend nowadays to support the 21st century education. Game based learning is an exploration of using game to achieve necessary learning outcomes (Kim et al., 2009) and it depicts a situation of which the content of the game and playing the game will enhance the knowledge and skills development (Qian and Clark, 2016). It has been further reported by Qian and Clark (2016) that the elements of critical thinking skills as one of the 21st century learning skills can be nurtured by using game based learning. However, rather than designing and developing education computer games, which requires much time and effort, the educators may resort to use commercially available games in game-based learning (Baek, 2006; Baek and Kim, 2005). Kafai (2006) demonstrated the differences between instructionist and constructionist point of view when it comes to game based learning. While the instructionists tend to create games and to be played by the learners, the constructionists guided the learners to create their own games for learning.

The aim of this research work is to promote high order thinking among the chemical engineering students, and importantly making them learn the Reaction Engineering subject using cooperative learning method outside of the classroom. This is implemented by developing instructing the students to develop a board game in the assigned group, incorporating the subject matters, given a complex instruction technique to solve the open-ended problems. Some multimedia elements such as video creation and editing and web design become the requirement to the students as the tools to showcase and demonstrate their project output, as part of nurturing their creativity.

2. Preliminaries

Universiti Teknologi PETRONAS (UTP) has been offering chemical engineering program since its establishment in 1997. The program gains many interests, attracting the local and international talents to further their study at UTP. In 2016, chemical engineering program is recognized as Top 150 World Ranking by subject by Quacquarelli Symonds (QS). In 2015, UTP is also awarded a Six-Star rating by the Malaysia Research