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A Problem-Solving Flipped Classroom Module: Developing Problem-solving Skills among Culinary Arts Students

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Abstract: Problem-solving skills are important at the workplace in Culinary Arts for initiating innovative and creative solutions. However, graduates from community colleges in Malaysia seem to have only average level of problem-solving skills, while instructors do not seem to emphasise developing problem-solving skills when conducting lessons. Hence, providing more opportunities in solving real-world problems for work is required. A Flipped Classroom approach begins with activities conducted with video lectures on key concepts and gatekeeper quizzes to be completed before class and in-class phase spent on applying concepts learned before class using problem-solving activities. In this study, a Problem-Solving Flipped Classroom (PSFC) module designed for students in the Culinary Arts programme in a Malaysian Community College based on Merrill's First Principles of Instruction and the Cognitive Apprenticeship framework was employed and implemented among 30 first-semester students and one participating instructor in a selected Community College. The single group pretest and post test quasi-experimental design was used to investigate the effectiveness of the PSFC module for learning and problem solving. Using *t*-test analysis, the findings indicated that the students had significant learning gains and improvement in problem-solving skills after using the module. Hence, the PSFC module could be used in Culinary Arts at other Community Colleges and TVET institutions to improve problem-solving skills among Culinary Arts students. This is to ensure a significant amount of instruction at Community Colleges include problem-solving instruction using authentic tasks at a level suitable for students to acquire problem-solving skills required in the workforce.

Keywords: Culinary arts education, problem-solving, first principles of instruction, flipped classroom

1. Introduction

Industry 4.0 is powered by exponentially growing disruptive technologies (Xu, David & Kim, 2018). The development of the Internet of Things, Artificial Intelligence and automation, has influenced all industries and has led to a change in employees' skill-requirements. The existing workforce and future graduates need to be prepared to adapt swiftly to industry 4.0. These disruptive technologies imply that new course content and skills are required for our graduates to be employable (Mashelkar, 2018). Technical and Vocational Education and Training (TVET) which adapts to industries' needs, ensures the development of a highly-skilled workforce for the economic advancement of a country nation (United Nations Educational, Scientific and Cultural Organization (UNESCO, 2016a). UNESCO's strategy is aligned with the Sustainable Development Goal 4 and addresses issues related to unemployment and equity (UNESCO, 2016b). Technical skills are required for highly technical tasks, while soft skills such as problem-solving, teamwork and communication are essential in day-to-day business. Hence, higher learning institutions need to impart technical and soft skills such as problem-solving, communication and creativity for graduates to be employable. More importantly, to survive in the job market of industry 4.0, human skills with the growing disruptive technologies, such as Artificial Intelligence, are unable

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to replicate, is required (Peters, 2017). In Malaysia, TVET higher learning institutions such as community colleges and polytechnics have been tasked to adopt Education 4.0 to develop talent and skilled workers for the employment sector for the workforce of industry 4.0 (Ministry of Education Malaysia, 2015).

Community Colleges in Malaysia provide lifelong learning opportunities for employability among the local community. As open-access institutions, they provide post-secondary students training to working adults who wish to upgrade their skills. 93 Community Colleges in Malaysia offer courses on multimedia, accounting, architecture, construction, engineering, and hospitality. Although the employability rate of graduates from these colleges is high (97.2% are employed within six months after graduation), the quality of the courses still needs to meet the demands of the industry (Mohd Yusof, 2010; Suhairom, Must'amal, Mohd Amin & Johari, 2015). The Certificate-level Culinary Arts programme is taken as an example. This programme has a high yearly enrolment but is only offered at eleven colleges (Techanamurthy, Alias, and Dewitt, 2018). Graduates from this programme would work in the food-service industry where problem-solving is essential. Industry 4.0 has impacted the industry as problems such as the strict requirements for food safety and changes in regulations in the food and beverage sector can be solved with technologies (Noor Hasnan and Yusoff, 2018). Graduates may face problems such as unexpected events, missing items in a delivery order, more than anticipated guests for a function, or a power supply disruption in their jobs (Deutsch, 2016). Hence, in the food-service industry, employees need a sound grasp of the culinary principles and not just repeat well-rehearsed routines (Soden and Pithers, 2001) and identify problems and initiate practical and creative solutions (Deutsch, Billingsley and Azima, 2009).

However, research indicates that students have low levels of domain knowledge and problem-solving skills. In the analysis of the problem-solving skills among 831 students, mostly aged 18-24 years, from the eleven colleges offering Culinary Arts in Malaysia, they had a moderate level of skills (Techanamurthy et al., 2018). Specifically, students scored lowest in analogizing, an essential skill for abstracting solutions from problems previously encountered (Techanamurthy et al., 2018). Without sufficient prior experience with solving problems, students would not use these strategies for solving real-world problems (Kauchak and Eggen, 1998). Hence, the culinary arts programme should provide more opportunities for using analogising and other modes of thinking such as causal reasoning, modelling and argumentation, to solve problems during the class sessions. Meaningful tasks using real-world problems are required so that these students develop subject matter knowledge and problem-solving skills (DeWitt, Alias, Palraj, & Siraj, 2018; Thompson, Poulston and Neill, 2017). In order to have sufficient time, theories related to the knowledge domain for culinary principles could be done before class so that there was more practice for problem-solving in the classroom. This study uses the exploratory-implementation approach as a research design and development (DeWitt, Alias, Ibrahim, et al., 2015). As usually done in such an exploratory study, a Problem-Solving Flipped Classroom (PSFC) module was designed to test its implementation to determine its effectiveness. The PSFC modules' effectiveness would be determined whether students have acquired any significant gains in the knowledge of the lessons tested in this study. It was also necessary to investigate whether the students' problem-solving skills improved. The first semester students studying Culinary Arts at the Community College were used as a single group for this participation. In turn, no control group was assigned.

1.1 The Flipped Classroom

The Flipped classroom (FC) was used for the module. The FC starts with a distinct out-of-class phase where activities could be conducted with video lectures and quizzes, while the in-class phase could be centred on problem-solving (Lo and Hew, 2017). The FC seems to provide students with opportunities to work on activities that enable them to apply knowledge to solve related problems (Critz & Knight, 2013; Lemmer, 2013; O'Flaherty & Phillips, 2015; Zaid Alsagoff, Baloch, & Hashim, 2014). The in-class session provides instructors opportunities to scaffold students while they solved problems in authentic situations (Fulton, 2012; Sankey & Hunt, 2013; Young, Bailey, Guptill, Thorp, & Thomas, 2014). Thus, having sufficient problem-solving activities for the work-place could be provided with the FC (James, Chin & Williams, 2014; Lemmer, 2013).

However, there is still insufficient evidence that FC can improve problem-solving skills. O'Flaherty and Phillips (2015) reviewed 28 studies on FC implementation and indicated that the approach might not ensure that students acquired problem-solving skills. Students may perceive that they improved in their communication skills and problem-solving ability when collaborative problem-solving was used, but there were still mixed findings on learning gains (Ferreri & O'Connor, 2013). Some studies showed improved achievement scores with the implementation of the FC (McLaughlin and Rhoney, 2015; Porcaro, Jackson, McLaughlin and O'Malley, 2016; Schlairet, Green and Benton, 2014; Tune, Sturek and Basile, 2013; Wilson, 2013; Wong, Ip, Lopes and Rajagopalan, 2014). However, there was no significant difference in achievement scores after the implementation of the FC in many studies (Blair, Maharaj and Primus, 2015; Davies, Dean and Ball, 2013; McCallum, 2013; Whillier and Lystad, 2015; Yong, Levy and Lape, 2015; Young et al., 2014). Hence, this study seeks to determine whether the FC with a problem-solving approach in the PSFC module, could be effective for instruction in Culinary Arts in a Malaysian Community College.

1.2 Merrills' First Principles of Instruction

The PSFC module aims to develop students' problem-solving skills by enabling them to applying theoretical knowledge in solving authentic problems. Firstly, the FC model by Lo and Hew (2017) has distinct in-classroom and out-of-classroom activities guided by the First Principles of Instruction (Merrill, 2007), was used.

Merrills' First Principles of instruction is a problem-centered approach based on real-world problem tasks and comprises four phases: activation, demonstration, application, and integration. The design of the module takes into account the theory of cognitive apprenticeship where the instructor is a facilitator who models (demonstrates) and shows how analogies are done, scaffolds (supports) causal reasoning, and gradually decreases guidance, and coaches (offers suggestions, feedback and hints to the student) for argumentation (Kerka, 1997).

In cognitive apprenticeship, the instructor is the facilitator who would guide the activation of prior knowledge, as he encourages the recall of structures for organising and building on the new knowledge (Merrill, 2007). During the demonstration of the new knowledge, the facilitator models as well as provide for the demonstration in the context of real-world tasks or problems to enable the learner to model the cognitive tasks and skills (Kerka, 1997; Merrill, 2007). During the application phase, students apply what they have learned by performing real-world tasks or solving real-world problems using the modes of thinking (Merrill, 2007; Techanamurthy et al., 2018). During the application, the facilitator scaffolds the learner and gradually decreases the support during the process (Kerka, 1997). During integration, students are allowed to integrate their new knowledge and transfer it to different situations for learning (Merrill, 2007). During the process, the facilitator guides and coaches the learner while offering suggestions, feedback and hints to enable articulation and reflection (Kerka, 1997). Hence, for this purpose, the PSFC module would employ the First Principles of Instruction in a cognitive apprenticeship framework for culinary arts.

2. Methodology

2.1 Population and sample

There are 11 Community Colleges offering the Certificate in Culinary courses in Malaysia, six in urban areas (Techanamurthy, Alias and Dewitt, 2018). During the needs analysis phase, the student population was surveyed to find out their levels of problem-solving solving skills and flipped classroom readiness (Techanamurthy, Alias and Dewitt, 2018). This study takes on a single group quasi-experimental research to determine whether the PSFC module was effective for learning and problem-solving. The module was implemented with 30 Culinary Arts students at a selected Community College with one participating female academic with nine years' teaching experience in the same college. The community college selected was in the central region and the participants in one intact group were willing to use the PSFC module designed. The 30 participants, 13 males and 17 females, comprised of 80% school leavers below the age of 20 years and the rest were between 20 and 24 years old in their first semester Culinary Arts Certificate programme.

2.2 Instrument

The instrument used were pre-tests and post-tests comprising two sections: the first section measured their learning in the cognitive domain while the second section evaluated their problem-solving skills. The knowledge domain had 20 multiple choice questions (MCQ) to test their theoretical knowledge. In comparison, two open-ended questions were employed to evaluate their problem-solving skills for decision-making and troubleshooting. The MCQ were scored according to the correct answer and the open-ended questions were evaluated for the problem-solving process using a rubric. The pre-test and the post-test items were content-validated by three experts in the field, from the same institution, who had more than ten years' teaching experience. Experts reviewed the items based on the outline of the module content to check if items were representative of the content being taught. Experts also reviewed the wording and layout of the contents, resulting in minor revisions made to improve the final versions of the tests.

To confirm the internal validity, the value of the alpha reliability coefficient (KR20) was established for both tests. The reliability coefficients were .713 and .644 for the pre-and post-tests, respectively. Alpha coefficients between 0.60 and 0.70 are considered acceptable (George and Mallery, 2003). The scores of the pre-test and post-test were based on the answer scheme. The quasi-experimental study's internal validity was increased due to the short time interval between the pre-test and post-test as the maturation effect would not be affected.

2.3 Data Analysis

Data collected from the scores of the pre-test and post-test before and after implementation respectively were analysed using a paired-sample *t*-test to determine if there was a significant gain in the scores after the intervention. The pre-test was administered three days before the implementation while the post-test was carried out three weeks after the intervention. This was to ensure that retention had occurred. A secret four-digit code was included on the pre-test instrument to ensure both the pre-and post-tests could be matched at the end of the study for the analysis. The students' learning gains would be used to determine the effectiveness of the module.

2.4 Treatment

Once the PSFC module was validated and improved in the second round, a cover letter and an implementation schedule were forwarded to the director of a selected urban Community College located in the Klang Valley. This was meant to acquire the necessary permission to implement the PSFC module. To gain access to the course, the course instructor, who was also interviewed during the needs analysis phase, agreed to allow the researcher to recruit the students who were given participating marks to participate in the study. They were not given any form of monetary reward.

The orientation to the module was held to introduce the module to the research participants in a two-hour workshop. Prior to the orientation workshop, the participants received a memo from the participating instructor via a WhatsApp group to also to watch several YouTube videos on Flipped Classroom and to install the EdPuzzle and Schoology app on their mobile devices. During the orientation workshop, the researcher explained the purpose of the research and explained how the instructor would implement the module. These measures were necessary as a pre-intervention step that helps students to be familiarised with the module (Findlay-Thompson and

Mombourquette, 2013; Gilboy et al., 2015). At the end of the briefing, a cover letter and an informed consent form were distributed to each participant of the study. All the participants agreed to participate in the research and returned the informed consent form on the same day. As a confidentiality measure, all the students were then randomly assigned a number that begins with one (1) and ends at 30. This coding technique will also facilitate the pre-test and post-test instrument administration. All the participants also received a copy of the informed consent form for them to keep. Due to the voluntary nature of the study, it was also made clear to students that they could end their participation in the study at any point and that their marks in the class would not be affected by their decision to participate or withdraw from the study. Following this, hands-on training to set up the learning platform (*Schoology*) and *EdPuzzle* application were conducted to enable participants to access the PSFC module.

The PSFC module was designed with resources for real-world problems and guidelines for instructors in implementing a problem-centered instruction based on Merrill's First Principles of Instruction and Cognitive Apprenticeship using a FC approach comprising of before class, during class, and after class activities. The module was implemented for nine lessons over three weeks to allow for the development of knowledge and scaffolds the development of problem-solving skills (Gosper, 2011). The Culinary Arts course comprised of five lessons on the theoretical components and four lessons for hands-on practicum. The lessons were on fundamental topics areas such as Standards of Professionalism, Kitchen Safety, Food Safety, and Kitchen Fundamentals that Culinary Arts graduates need to grasp well (Birdir & Pearson, 2000; Hornig & Lee, 2009; Lin & Cherng, 2006; Abdul Rahman et al., 2011).

All the lessons had a "Before class" and "After class" session. Before class activities involved the activation, demonstration and application phases, and video lectures were employed with quizzes and structured questions (Lo and Hew, 2017). During this phase, activation of prior knowledge and demonstration using mini-lecture strategies to demonstrate the tasks centred on the problem to be completed was done. After the mini-lectures, students could apply the knowledge learned by answering quizzes so that they could analyse their responses to the questions in the application phase. The delivery of the content was through a Learning Management System (LMS) and was supported with the mobile instant messaging system, *Telegram*. During class, the activation, application and integration phase were done (Lo & Hew, 2017). The instructor reviewed the video lecture to clarify any misunderstandings during the activation phase. Students then applied the concepts learned by solving simple problems, either individually or in pairs. Students could later apply their knowledge in solving more advanced or real-world problems in groups, supported by the instructor and peers during the integration phase. After class, students were asked to record their reflections and to submit the audio recordings on *Telegram*. The instructor reviewed these recordings and corrected misconceptions to guide the learners to articulate their understandings during the problem-solving. The implementation of the PSFC module is shown in Figure 1.

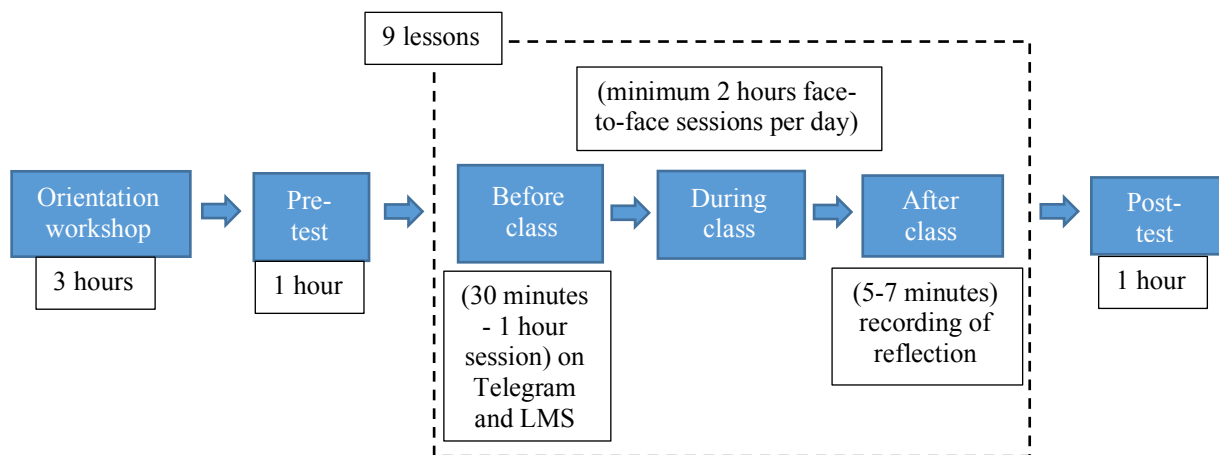


Fig. 1 - The implementation of the PSFC module.

2.5 Data Collection and Analysis

The module's effectiveness was measured from the participants' achievement scores in the knowledge domain and in problem-solving. Data included the means and standard deviation of the scores and the paired sample *t*-test to evaluate the students' learning gains score after the implementation of the PSFC module to determine effectiveness. Since this study focused on a single instance of the FC intervention, with a small population of students, the students' learning's normalised gains were measured by the pre-test/post-test score differences (Talbert, 2014). Therefore, the effectiveness of the PSFC module was established by using the pre-test/post-test model, with calculations of the various measures of learning for the knowledge domain and problem-solving, including measures of the class-average and single-student normalised gains.

3. Findings and Discussion

The findings of the effectiveness PSFC module, after implementation, were interpreted using both descriptive and inferential analysis. The descriptive analysis involved the mean and standard deviation of the PSFC module, whereas the inferential analysis involved the *t*-test. The following null hypothesis was formulated:

- i. There is no significant difference between pre-test and post-test scores in terms of learning gains following the implementation of the PSFC module.
- ii. There is no significant difference between pre-test and post-test scores in terms of problem-solving following the implementation of the PSFC module.

All the 30 students participated in the pre-test and post-test. The analysis of the findings indicates that there was an increase of scores in the post-test among the majority of the students when compared to the pre-test. The *t*-test analysis indicates a statistically significant difference in the scores obtained in the knowledge domain for pre-test and post-test; $t(29) = 12.458$, and $p = 0.000$. Hence, there was a significant difference in the knowledge domain after using the PSFC module (see Table 1).

Table 1 - Descriptive statistics, mean and standard deviation for the pre-test and post-test in the knowledge domain.

| Paired Differences | | | | | | |
|--------------------|-------|----|------|--------|----|---------------|
| Test | Mean | N | SD | T | df | Sig(2-tailed) |
| Pre-test | 13.40 | 30 | 5.15 | 12.458 | 29 | 0.000 |
| Post-test | 30.80 | 30 | 4.91 | | | |
| Gain | 17.4 | | | | | |

* $p < 0.005$

The *t*-test analysis indicates a statistically significant difference in the scores obtained in problem-solving for pre-test and post-test: $t(29) = 17.943$, $p = 0.000$. Hence, students had a significant gain in problem-solving skills after using the PSFC module (see Table 2).

Table 2 - Descriptive statistics, mean and standard deviation for the pre-test and post-test problem-solving.

| Paired Differences | | | | | | |
|--------------------|-------|----|------|--------|----|---------------|
| Test | Mean | N | SD | T | Df | Sig(2-tailed) |
| Pre-test | 17.63 | 30 | 7.92 | 17.943 | 29 | 0.000 |
| Post-test | 50.40 | 30 | 6.97 | | | |
| Gain | 32.77 | | | | | |

* $p < 0.05$

The findings from the one group pre-test/post-test, quasi-experiment showed that the null hypothesis was rejected. Thus, there was a significant difference between the pre-test and post-test mean score regarding learning gains with $t(29) = 12.458$, and $p = 0.000$, and problem-solving with $t(29) = 17.943$, and $p = 0.000$ following the implementation of the PSFC module. The results of the high learning gains reflected those of McLean, Attardi, Faden, & Goldszmidt (2016), who found that tasks completed for "before class" session allowed students to interact meaningfully with the content presented. In addition, the First Principles of instruction used in the PSFC module improved learning. The activation phase was useful as instructors could now determine students' level of prior knowledge as they most had work experience (Merrill, 2007). The demonstration phase also helped improved understanding as when students watched the videos before class, they learned better in the cognitive and problem-solving domains, as well as practical work. During the application and integration phases, the students shared videos that could help them with their tasks, such as vegetable cutting, on *Telegram*. In addition, they also scaffold their friends on the platform. Hence, the problem-solving activities conducted during class reinforced the concepts learned in a way that enabled students to connect and apply the concepts and ensure effective problem-solving (Kong, 2014; Lo & Hew, 2017; McLaughlin & Rhoney, 2015). This indicates that

Merrills' First Principles and Cognitive Apprenticeship could improve students' understanding and skills in applying the fundamental concepts of Culinary Arts for solving authentic problems.

4. Implications and Conclusions

The findings of this study indicate that the PSFC module can encourage learning gains by using problem-solving activities in Culinary Arts classrooms. In linking the contribution of current research to the theoretical aspect, it can be said that this study had developed a module based on the combination of the following: the FC Model based on the First Principles of Instruction (Merrill, 2002), Cognitive Apprenticeship (Collins, Brown and Newman, 1990) and the FC Model using the First Principles of Instruction (Lo & Hew, 2017) for the design of flipped problem-solving in Culinary Arts in TVET settings. The study responds to the call made by Deutsch (2016) and Soden and Pithers (2001) who highlighted that the traditional culinary teaching practices inhibit students' ability to think innovatively which is required when they join the workplace environment. It is interesting to note that the t-tests on the pre-test/post-test results indicate that students displayed improved cognitive learning gains and problem-solving skills at the end of the study.

The findings also suggest that problem-solving skills are improved by exposure to authentic, real-world problems during instruction. This would seem to support Merrills' First Principles of Instruction (2007) that focuses on knowledge building and learning is promoted when learners are engaged in solving real-world problems. This information is important given that past studies provided little empirical evidence that problem-solving skills improved following FC intervention. One explanation for this finding is that authentic activities sequenced from simple to more complex real-world tasks, examples of how knowledge is applied, access to experts, and a social context in which students collaborate and construct knowledge for problem-solving in the PSFC module may influence learning. The findings also showed that the explicit learning phases of Merrills' model make it easier to conceptualize and implement for practitioners, and better engagement and learning was reported (Hoffman, 2014; Wang, 2017). The results of this study are significant for instructors and curriculum designers in TVET education. Future studies could focus on the use of PSFC prototype as a model for problem-solving instruction in Culinary Arts courses at other Community Colleges and other TVET institutions offering Culinary Arts programme in Malaysia. It is also hoped that the PSFC prototype can also be used as a model for problem-solving instruction for other subjects taught at Community Colleges.

Further, Education 4.0 is a new era of combining technology into almost every didactic education element (Bongomin, Ocen, Nganyi, Musinguzi & Omara, 2020). The technology trend of the education system is quite similar to the industrial revolution. Therefore, the more crucible way to build industry 4.0 is through proper adaptation of synergy models between academia and industry. The industry-academia is capable of imparting both technical and soft skills to the human workforce of industry 4.0. Instructors should work with practitioners and industry experts to develop real-world problems that can be used in instruction. This ensures a significant amount of instruction at Community Colleges includes problem-solving instruction using authentic tasks at a level suitable for students to acquire problem-solving skills required in the workforce. By incorporating the learning and working environment from which realistic and relevant learning experiences arise, a two-way knowledge transfer channel becomes the basis of synergy models between academia and industries.

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