Development of Team-Based Electronic Portfolio in the Teaching & Learning of Ordinary Differential Equations

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Abstract—*Obtaining evidence of student learning is a vital aspect in acquiring accreditation of programs in institutions of higher learning. With the limitations of the traditional assessment approach of pen and paper as a measuring tool, educators seek for alternative assessment methods that are able to measure other than technical skills. E-portfolio is an example of such an alternative. However, with a large class size of over two hundred students, implementation could be an obstacle. The author thus implements team-based e-portfolio that requires students to work collaboratively. The objective of the team-based learning e-portfolio assessment is to develop an e-portfolio that consists of biographical details, solutions to application problems in first order ordinary differential equations, students' reflections of learning experience and evaluation of the course and delivery from students' perspective. The implementation of the e-portfolio assessment is to measure participants' process skills, i.e. in terms of communicating, organizing, classifying, constructing and designing using multi-media skills, analyzing, evaluating the course and their instructor education delivery and reflecting on their learning endeavor in building the e-portfolio as an integral part of their learning assessment. How do participants rate such an assessment approach? The objective of this research is to discover participants' feedback and rating towards the e-portfolio assessment in the teaching and learning of the Differential Equations course. This paper intends to discuss the outcomes of the implementation of team-based e-portfolio assessment from the learners' point of view. The study employs a single group ex-post facto quantitative and qualitative research. Two hundred and forty two first semester engineering students of Universiti Tekologi PETRONAS (UTP) are involved in the study. These students are in the Petroleum Geosciences, Petroleum and Mechanical Engineering discipline enrolled for the July 2009 semester. All participants have at least passed the pre-requisite of passing a four-credit-hour Calculus course at UTP, or an equivalent course obtained from other institutions of higher learning. After five weeks of lectures on first order ordinary differential equations, the instructor posts structured instructions pertaining to the development of the e-portfolio using the university electronic learning support system; moodle. The online information includes a definition of the e-portfolio, the objectives of the e-portfolio development, and complete instructions with the provision of an e-portfolio template as a guide for participants. Using random sampling, the participants form groups of five. Participants team up and select five questions from a pool of twenty problems. The researcher gives a short demonstration of Power Point with animation and Microsoft Equation Editor Version 3.0 that participants will need in order to develop the e-portfolio. Most of the participants are quite familiar with Power Point but not the animation tools and almost all never knew about the existence of the Equation Editor. For this paper discussion is focused on data collected at the end of July 2009 semester from a questionnaire, participants' ratings and their reflections of their learning experiences. The deliverables reflect participants' process skills and the feedback provide useful information to the instructor and evidence of student learning for accreditation purposes.*

Index Terms — *Student learning, team-based e-portfolio development, process skills.*

INTRODUCTION

Universiti Teknologi PETRONAS or UTP is a wholly owned subsidiary of PETRONAS, Malaysia's Oil and Gas Company. Being a multi national company, PETRONAS sponsors students from more than 30 countries, worldwide, and provides the opportunity of higher education in UTP. Thus, the medium of instruction used in UTP is English, to cater for the multi national student population on campus. In striving for excellence, UTP seeks for a continual quality improvement in fulfilling the requirements of outcome-based education, meeting industrial needs and stakeholders' demands. The programs in UTP, at undergraduate and postgraduate levels focus on engineering and technology. For quality assurance in education, concrete evidence of student learning is necessary in fulfilling and maintaining accreditation requirements spelled out by the Engineering Accreditation Council, Malaysia [1]. Providing such evidences would require more than just showing abilities of cognitive thinking in students' learning, but should also encompass other aspects, namely those in affective and psychomotor domains. For institutions of higher learning to produce well-balanced engineering graduate and successful in meeting the market demands, the provision of quality education and adequate training are indispensable. Enlisting the qualities of a great engineer, the top ten are 1. Possesses a strong

analytical aptitude. 2. Shows an attention to detail, 3. Have excellent communication skills, 4. Takes part in continuing education, 5. Is creative, 6. Shows an ability to think logically, 7. Is mathematically inclined, 8. Has good problem solving skills. 9. Is a team player. 10. has excellent technical knowledge [2] . What type of assessment methods are installed to measure students' learning in preparation for such well-balanced graduates? Assessment is an ongoing process that involves planning, discussion, consensus building, reflection, measuring, analyzing, and improving based on the data and artifacts gathered about a learning objective. [3] .It encompasses a range of activities including testing, performances, project ratings, and observations [4]. Apparently, the pen and paper assessment method has its limitations as a measuring tool of learning. Educationists have opted for other direct alternatives and learning portfolio is one such example [5]. The learning portfolios are now commonly used in nursing education, both as a tool for reflective learning and as an innovative way of documenting student learning and evaluating clinical competence [6]. As technology advances, the learning portfolio experiences its own transformation; from paper-based which consumes huge storage requirement with time, to that of the digital or electronic-based, capable of addressing the issue of physical space consumption. Studies have shown that although portfolio assessment is time-consuming, the implementation of the learning portfolio proved to be rewarding in terms of students' learning and as a measuring tool. The employment of such an alternative assessment was used to measure learning abilities of eight students, in the curriculum of the Department of Computer Education and Instructional Technology and it was found that e-portfolio assessment proved to be valuable in project-based learning [7]. The recommendation made was to involve more participants. The results of a study involving 29 participants, aimed at measuring students' perceptions of their achievement of the nursing program's goals and objectives indicated that portfolio evaluation is an effective tool for documenting achievement of program objectives [8]. Would it however, be possible to implement e-portfolio as an assessment method in the teaching and learning of a course with a bigger number of students? A study was done using paper-based learning portfolio as an integrated assessment method in the teaching and learning of Calculus involving one hundred and nine electrical and electronic engineering students in the UTP Foundation Program, and it was found that it not only assist them in learning but also promotes organization and discipline within themselves [9]. This paper intends to discuss the outcomes of incorporating the e-portfolio as part of the assessment method in the teaching and learning of Differential Equations or e-DELP to two hundred and forty two first semester engineering undergraduates in UTP. The entire assessment approach included traditional ones (written tests) and other alternatives such as e-DELP development, peer assessment, and individual presentation. Quantitative and qualitative data collection was done through several means that included the traditional and the alternative means. Some qualitative data such as those concerning the development of e-DELP, peer evaluation, and the individual presentation are quantified for the evaluation purposes with the help of criterion-based scoring rubrics. This paper will focus on discussing the pretest and posttest results, participants' opinion as to their rating of e-DELP, also discuss the verbatim findings from the participants' reflections of learning experience. The method of implementation produced intriguing and encouraging outcomes. In search of a better approach of assessing students' learning abilities, the learning portfolio is one of the alternatives to the traditional pen and paper method that is regarded as a rich learning tool [10]. Reference [11] shows that the use of the learning portfolio as a base for assessment is now well established as a valuable assessment. There are numerous definitions of portfolios offered by researchers. Amongst them are; A purposeful collection of student work that exhibits the student's efforts, progress and achievements in one or more areas. The collection must include student participation in selecting the contents, the criteria for selection, the criteria for judging merit and evidence of student self-reflection [12]. Reference [13] found that 77 percent of the variations in attitude toward the course were the instructor, course topic, course execution, and the room (physical environment). A portfolio is more than a 'folder of student work; it is a deliberate specific collection of accomplishments [14]. A portfolio is a formative assessment wherein students become active learners and questioning thinkers. [15]. It can be defined as a collection of learner's work that demonstrates achievement or improvement [16]. Educationists defined the learning portfolio many different ways, depending on its purpose and objectives. The electronic Differential Equations learning portfolio in this research, named e-DELP is a team-based electronic portfolio and it is aimed at measuring students' learning abilities in applying their knowledge, aptitude and attitude while organizing, assembling, presenting, communicating, utilizing multi-media, and working in a team. The deliverable is a learning material on a compact disc, which contains their biographic details, solutions to modeling problems involving first order differential equations, their evaluation of the course and delivery, and reflections of their learning experience vital for continual quality improvement.

METHODOLOGY

Two hundred and forty two participants involved in this research were all UTP undergraduates in the engineering disciplines; petroleum geosciences, petroleum engineering and mechanical engineering enrolled for the July 2009 semester. They were in their first semester of a four-year engineering degree program. Participants; 180 males and 62 females were of multinational; Malaysian, Indonesian, Siamese, Vietnamese, Egyptian, Turkmen, Uzbek and Burmese (Myanmar). These participants have at least passed pre-Calculus and Calculus courses. Only one participant has had a previous experience of doing an e-portfolio project for an agricultural course in his native land of Indonesia, whilst for all others, it was a first time experience of doing e-portfolio assessment for a mathematics course. The two hundred and forty two participants were randomly confined into teams of five. The research was a single group ex post facto design,

where the formation of the group was not manipulated. The program enrolment of participants in the July 2009 semester determined the formation of the group. A pretest and a posttest were employed before and after the e-DELP implementation, which consumed seven weeks. The e-DELP was an integral part of the course assessment worth 10% of the entire coursework, and it commenced in week 5 of the fourteen-week semester and ended at the end of week 12. At the onset of week 5 of July 2009 semester, the official random grouping of participants was released, with a set of structured instructions on the university e learning. The self-constructed instructions served as a guide for the e-DELP development included a definition of e-DELP, its objectives, the contents expected, the required tools, mode of submission and the project submission deadline. Participants were required to use Power Point Presentation with animation and linkages, Microsoft Equation Editor, and incorporate audio and visual effects into their e-portfolio. Constructing the e-DELP also meant doing some research on the correct mathematical model required to enable them to solve the application problem. The instructor provided guidance but no answers to the problem-solving component and participants had to be independent of the instructor and collaborate more with their teammates.

An e-DELP template was posted on e learning via moodle so that participants could use as it a basis in creating their own version. Three distinct criterion-based scoring rubrics were posted for participants information concerning the details of what was expected of them; for the development of e-DELP, peer evaluation in the development of the team-based e-DELP, and for individual presentation [17]. The e-DELP content expected of the participants made up of four components; their demographic details as team members, the solutions to the modeling problems involving differential equations, the evaluation of the course and its delivery, and the reflections of their learning experience of the course. Each team had the freedom to write in either individually or collectively as a group opinion. Submission of e-DELP was in week 12 of the semester, and each individual assessed his/her peers during a 10- minute meeting session with the researcher. During this short session, the researcher asked each participant his/her rating of the integration and the development of e-DELP as an assessment method. All e-DELP data was gathered and compiled by week 14 of the semester. Evaluation of e-DELP was based on a scoring rubric, but to ensure fairness, one score did not fit all in a team, each team member was subjected to peer evaluation. A criterion-based scoring rubric developed online to evaluate the e-DELP development [17]. The e-DELP evaluation considered nine different categories; Buttons and Links work correctly , background , Sounds-planning, Originality, Text - font Choice & Formatting , Content - Accuracy , Spelling and Grammar , Use of Graphics , and Effectiveness . The quantified scores of 4 to 1 for e-DELP evaluation to indicate those meeting the best criteria to the least respectively ;

- 4 marks indicate exemplary i.e. the description of identifiable performance characteristics reflecting the highest level of performance,
- 3 marks indicate accomplished, i.e. the description of identifiable performance characteristics reflecting mastery of performance.
- 2 marks indicate developing, i.e. the description of identifiable performance characteristics reflecting development and movement toward mastery of performance,
- 1 mark indicates beginning, i.e. description of identifiable performance characteristics reflecting a beginning level of performance.

For the peer evaluation, the quantifiers for f were according to the prescribed indicators [17];

- 1.00 to indicate that student was an engaged partner, listening to suggestions of others and working cooperatively throughout lesson
- 0.75 to indicate that student was an engaged partner but had trouble listening to others and/or working cooperatively
- 0.50 to indicate that student cooperated with others, but needed prompting to stay on-task
- 0.00 to indicate that student did not work effectively with others

To ensure fairness in the award of scores, an average peer evaluation score, or a moderating factor, f, was obtained such that $0 \leq f \leq 1$. The factor f was used as a multiplier to the e-DELP score, P. Each member in a team will thus earn a score of $f * P$. An 8-item questionnaire designed by the author was dispensed and responses by participants were based on the Likert scale of 5 for 'strongly agreed', 4 for 'agree', 3 for 'neutral', 2 for 'disagree', and 1 for 'strongly disagree'. The questionnaire employed was tested for its reliability and its Cronbach's alpha was 0.8259, with reliability item alpha value of 0.8279, suggesting that it was reliable. Items in the questionnaire are as per listed shown in Table 1.

Items	Statements
1	I learnt a lot from doing e-portfolio assessment.
2	I enjoyed doing DE modeling problems for e-portfolio assessment.
3	The Problem-Based Learning in e-portfolio assessment is an excellent idea.
4	The teamwork in my e-portfolio project group is excellent.
5	The instructions provided in doing the e-portfolio Assessment in DE is excellent.
6	I have definitely benefited from e-portfolio assessment in my learning of DE.
7	Overall, I am satisfied with the way my DE learning is assessed (using e-portfolio).
8	Overall, with e-portfolio I have enjoyed learning the DE course.

TABLE 1
ITEMS IN THE QUESTIONNAIRE EMPLOYED

For the purpose of this paper, discussion of results will focus on the participants' feedback concerning the questionnaire, their rating of e-DELP as an integral part of the assessment method in the teaching and learning of the Differential Equations course. The researcher used Microsoft Excel and the statistical package for social sciences or SPSS to analyze and represent the data gathered.

RESULTS AND DISCUSSION

Quantitative and qualitative data were gathered through several learning tools; the pre and posttest, written tests, the e-DELP scores, peer evaluation, individual presentation, the questionnaire, the participants' rating of the e-DELP, and participants' reflections of their learning experience. Out of a full score of 10 points, the mean values of the pretest and posttests were 1.3750 and 7.1563, respectively. Table 2 shows 128 participants took part in the pretest and posttest and that the mean value for the pretest was 1.375 with a standard deviation of 2.5379 while the mean value for the posttest was 7.1563 with a slightly bigger standard deviation of 3.19802. This means that the measure of dispersion from the mean value for the pretest was smaller when compared to the dispersion from the mean value of the posttest.

Tests	Number of Participants	Mean	Standard Deviation	Standard Error Mean
Pretest	128	1.3750	2.53790	0.22432
Posttest	128	7.1563	3.19802	0.28267

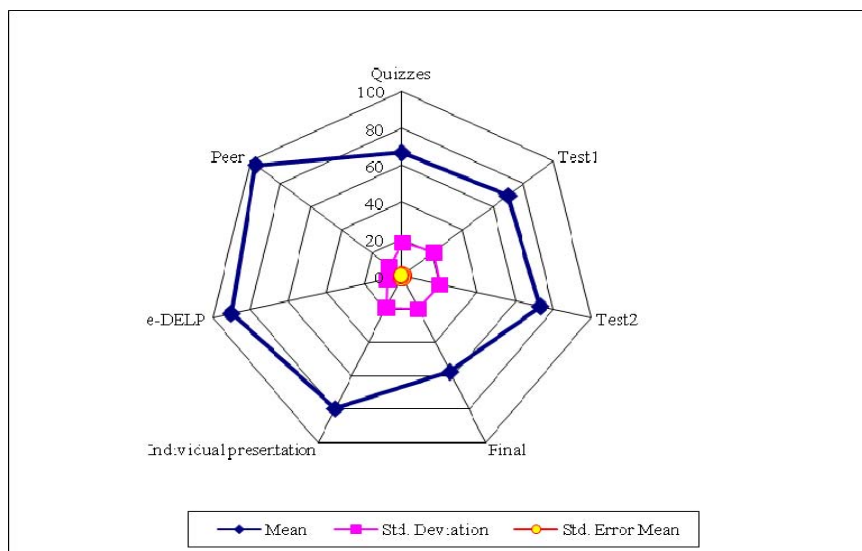TABLE 2
STATISTICS OF THE PRE AND POSTTESTS

FIGURE 1
STATISTICAL REPRESENTATION OF SCORES

The radar chart in Figure 1 shows the participants' mean scores in the written tests, quizzes, a final examination, individual presentation, e-DELP, and peer evaluation. It shows the highest of the mean scores was obtained from peer evaluation, followed by e-DELP development, individual presentation, and the written tests; the least was obtained from the comprehensive written final examination. Two hundred and thirty two participants responded to the questionnaire and the results were as shown in Figures 2 and 3.
Generally, all items earned mean scores of over 4.2 out of a full score of five, with standard deviation not more than 1, indicating a normal distribution and accounting for about 68% of the people sharing a common feeling towards e-portfolio assessment and its implementation. This signified a positive attitude towards such an assessment approach.
Figures 2 and 3 showed that item 2 which referred to "I enjoyed doing DE modeling problems for e-portfolio assessment" although recorded the lowest mean score of 4.2543 over 5.00, with standard deviation of 0.66739, indicating that most participants' were of this opinion. The item 4, which referred to "The teamwork in my e-portfolio project group is excellent", has the highest mean score of 4.5388, with a standard deviation of 0.63672, also indicating that most of the participants shared this opinion.
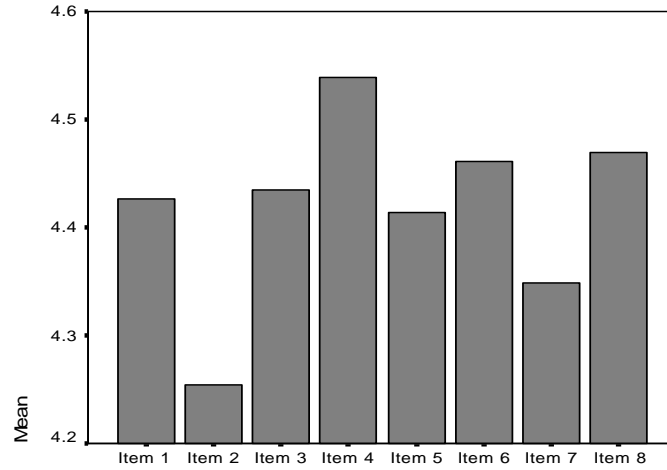
FIGURE 2

COLUMN REPRESENTATION OF PARTICIPANTS' RESPONSES TO QUESTIONNAIRE

Items 6 and 8, which were "I have definitely benefited from e-portfolio assessment in my learning of DE" and "Overall, with e-portfolio I have enjoyed learning the DE course", respectively indicated participants felt that the assessment method had helped them, and most important, they had fun doing the Differential Equations course. What did the participants feel about the development of the e-DELP and its integration as apart of the course evaluation?
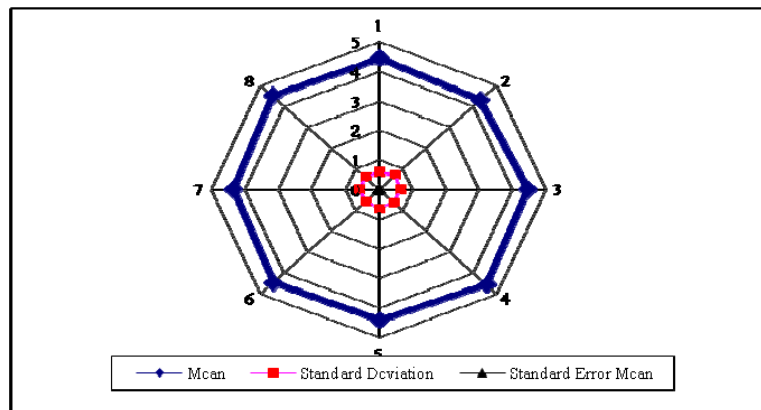

FIGURE 3

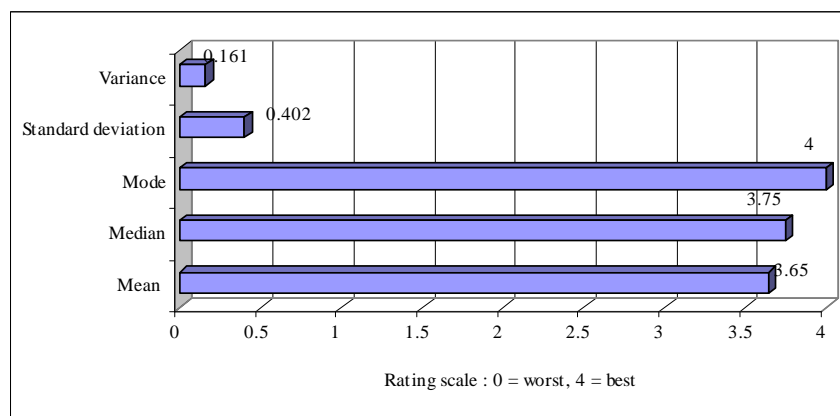PARTICIPANTS' RESPONSES TO THE 8-ITEM QUESTIONNAIRE

FIGURE 4

BAR CHART REPRESENTATION OF E-DELP RATING BY PARTICIPANTS

The bar chart in Figure 4 displays the statistical analysis of participants rating of the team-based e-DELP implementation. Of the full score of 4, the mode is 4, with mean 3.65, and the median or central score 3.75. The variance of 0.161 is very small indicating that the participants' feeling about the rating of 3.65 was close amongst themselves. In other words, participants favored the development of e-DELP and its implementation as an integral part of their course evaluation. The participants were asked if they would prefer the e-DELP be implemented on individual basis, and the answer was unanimously negative.

Table 3 shows participants' reflections of their learning experiences of the course. They responded to the following questions; What have you learnt? Why did you learn Differential Equations? How did you learn Differential Equations? Is doing e-portfolio something beneficial to you? Why? How? What can be done to improve your learning experience?

Reflections of learning experiences
Doing this portfolio have been quite beneficial for us all since the problems brush up our problem solving skills in mathematics and algebra equations. Besides that, we can improve our computer skills in Microsoft power-point as it will be very useful for our presentations in future.
This portfolio has definitely brought us to a better and deeper understanding of this subject. Differential equations is like the core subject for engineering students. This is because we use it in solving real life problems in the engineering field. There's a thousand ways to use differential equations in solving problems!
This portfolio has brought us together too. By doing it in groups of five, we managed to get to know each other better and develop teamwork skills. By discussing and solving the questions together, we learned better and faster.
This portfolio definitely brings us a lot of benefits. Though it might be tough, but by doing it together as a team, solving it could never be impossible.
Is doing this portfolio beneficial to us? Definitely yes! By doing this portfolio, we can help each other in solving the question. Those questions are very helpful as they make us think and find ways to solve them. If we could not solve a question on our own, we still have other members who might be able to assist us. Besides, we also make new friends through this portfolio. We are grouped randomly by our lecturer so that we will not only stick with our own clique. A group of five members who belong to different sex, religion and races make us understand our nation better.
We realize that e-portfolio of Differential Equation is a very beneficial and informative course because It does helps us during our study. The questions that had been given needs us to think outside of the box as it is an application problems which requires further understandings of a concept.
Having e-portfolio as one of our assignments helped us to understand differential equation better especially when methods that we have learnt are applied to real life problems. E-portfolio is indeed a beneficial group project which empowers peer discussions in solving and understanding differential equations. By working in a group, better learning experience is obtained. We truly support such method besides typical lectures.
Doing the e-portfolio as part of the coursework for Differential Equation is definitely beneficial to me. Why? Because it helps us in sharpening and enhancing our skills in solving mathematical problems be it using differential equation method or not. It also helps us in developing team work and a spirit of togetherness. How do we achieve all this? First of all, we are able to develop our mathematical skills by applying it in solving the mathematical problems given to us
Doing this e-portfolio is actually very beneficial and important because it deepened our understanding in differential equations, calculus and also pre-calculus and apply it in our daily life such as to estimate the temperature of the coffee after a while given initial temperature and temperature of surrounding. Besides the knowledge, we also get to work together as a team and get know each other further as students. We helped out each other to make this e-portfolio a success. So, completing this e-portfolio perfectly really matters and important for each and every one of us.
Differential Equations is a course critical for an Engineering students, thus making it a necessity for us to take this course. However, the reason behind why we took this course is to help us pass with flying colors in the understanding of DE. We focused in class to understand each and every aspect on what is being taught. We discussed in two-way communication with the lecturer to help us understand more.
Solving them in exercise books does not proof anything to why we are learning this subject. Then, came the assignment, which was an instant eye opener. From here, we understood on how to apply it in our daily lives, with some help that came from other application books on various ways to apply DE in daily life. The five sections given gave a clear view on why we are learning this subject as a whole.
By doing the e-portfolio, we get an overview on how the differential equations method of solving can be used in real life situation.
Doing e-portfolio is indeed beneficial to us because we learn how to solve the problem by using the correct method and formula.

TABLE 3
EXCERPTS FROM REFLECTIONS OF LEARNING EXPERIENCE

DISCUSSION

The best mean performance score obtained was in team evaluation which was 96.5054% and this was further supported by peer evaluation which recorded the highest mean score of 4.5388 from the maximum of 5, with a standard deviation of 0.63672, the participants showed that they were satisfied with the team-based e-DELP. When asked whether e-DELP would have been better if implemented individually-based, participants confirmed negatively. With a large number of participants of over two hundred, e-DELP was appropriately done team-based.

Participants feelings towards the integration of e-DELP was measured using the questionnaire and the mean scores obtained were all exceeding 4 with standard deviation of less than 1 suggesting that the implementation was appropriately done and generally accepted by the participants. This was further supported by the e-DELP ratings proposed by participants, which achieved a mean score of 3.65 and mode of 3.75, and a standard deviation of 0.402.

The implementation of e-DELP in this research differs from the implementation of learning portfolio assessments done in [6] and [7] since it involved a far bigger number of participants. The execution of e-DELP incorporation as an integral part of the evaluation of participants' learning received a high rating that suggests the approach was favorable.

At the same time, the participants exercised their ability in evaluating an assessment technique. Reference [18] mentioned that Bloom's Taxonomy of Educational Objectives, evaluation is considered the highest level of ability in the cognitive domain [19].

The significant improvement in the posttest when compared to the pretest shows that the e-DELP implementation was beneficial to participants, in terms of their abilities in solving the modeling problems involving first order Differential Equations. This is further supported by the excerpts indicated in Table 3, where participants admitted that they have found e-DELP beneficial.

CONCLUSION

Results of this research indicate participants' positive attitude towards the e-DELP implementation with respect to learning the course. The responses obtained from the participants' reflections of learning experiences also indicated that by doing e-DELP, they realized the reasons for doing the Differential Equations course. The participants preferred the team-based concept as their average peer evaluation recorded a high score indicating their attitude towards working collaboratively in completing their project. All teams submitted their work on time also illustrate strong teamwork, preferred attitude and discipline in meeting the deadline, of which hopefully, prepares them for the future working life as engineers.

Generally the integration of the team-based e-DELP was well received and accepted with contentment amongst the participants. A significant improvement in their abilities of solving the modeling problems also signifies effective learning process took place. The high peer assessment scores indicate strong teamwork within the groups and this had influenced their attitude towards the e-DELP development. The limitations of this research are that it was done on UTP campus, a Malaysian private university, involving only first semester engineering undergraduates. The scope of study could be further extended to other local private and public universities involving engineering undergraduates of more advanced semesters.

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