Impact of Engineering Final Year Project Research Method on Student's Development in Knowledge Construction

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Abstract — This study x-rays the impact of research method on knowledge construction of Final Year Project (FYP) students. The study is aligned with the Malaysian Qualifications Framework (MQF) level 6 for bachelor's degree. The procedure involved a reassessment of FYP thesis submitted by 18 graduating students in engineering. The assessment reconfigured the FYP rubrics focusing on knowledge construction. A comparison of the level of knowledge construction between the 10 students that used simulation software for their research investigations and the 8 students that conducted experiments in their finial year projects was conducted. The reassessment of the reports focused on the methodology and results presentation with consideration on the following criteria, understanding of the physics of the project area, presentation of procedure of operation, creation of new knowledge from project investigation, and justification of claim in line with underlying physics. The results showed that students that used software did more reflection on the underlying physics in the project areas than those that conducted experiments. It was also observed that the students that conducted simulations could investigate many parameters thereby creating new hypothesis to be proved through experiments. It was observed that students who used software exhibited high level of knowledge construction in developing research methods more than students that conducted experiments.

Keywords — Learning and Teaching, Information and Communication Technology, Knowledge Construction, Simulation Software

I. INTRODUCTION

ENGINEERING as applied science and technology requires the students to develop in critical reasoning in line with the ethics of the profession. At the tertiary level leading to the qualification of Bachelor which is classified as Level 6 in the Malaysian Qualifications Framework (MOHE 2011), the final year project students should be able to apply the knowledge gathered in their course of study for investigation, analysis, synthesis and evaluation in a given engineering project (Abdul-Talib 2011). The learning outcomes for Final Year Project (FYP) in engineering have been reportedly scattered and not necessarily aligned with a specific pedagogy of learning and teaching (Willey, Jarman, and Gardner 2008, Lee and Lai 2007). Thus, Jawitz, Shay, and Moore (2002) present FYP as culminating learning experience of engineering program which reflects the quality of a program in totality when considering the output of students. Thambyah (2011) identifies that setting learning outcomes for the FYP is based on the nature of the area of study which, in engineering, requires open-ended approach to problem solving. This is because engineers are required to apply theoretical knowledge to problem solving which does not necessarily follow structured procedure in some cases. Thambyah (2011) further infers that it is difficult to standardize learning outcomes and assessments for the FYP at subjective domain of research and design. The above point does not hinder the importance of knowledge construction from the activities of FYP which is the major activity that it should focus on. To evaluate an FYP on the basis of knowledge construction, Vitner and Rozenes (2009), Willey, Jarman, and Gardner (2008) and Jenkins et al. (2002) have made recommendations on how to devise learning outcomes for FYP. The works show some of the strategies employed in the alignment of the expectations in projects to learning outcomes which are linked to graduate attributes as enshrined in the university mission and as defined by the accreditation bodies (Jenkins et al. 2002, Willey, Jarman, and Gardner 2008). Similarly, the outcome of a FYP should reflect the expectations in the workplace of graduate engineers (Vitner and Rozenes 2009).

The researches on Final year Project have mainly focused on learning outcome which should reflect the knowledge construction in the evaluation. Considering the fact that there is limited view on the effect of ICT on knowledge construction based on Final Year Project assessment, this study focuses on the assessment and the findings on knowledge construction with reference to the use of ICT software. This paper reflects the knowledge construction and application of knowledge in Engineering considering the observations on the performance of students who employed software for their study and the students that conducted experiments.

II. METHOD OF INVESTIGATION

The study focuses on the assessment of 18 final year project thesis supervised by the authors from start to finish. The 18 students took their projects between January 2016 and June 2017 where the students conducted their researches in fluid flow and heat transfer systems. Out of the 18 students, 10 students conducted their Final Year Project investigations using Information and Communication Technology simulation software while 8 of the students used experimental models and conducted experiments for their finial year projects. The students that used simulation software employed any of the following Computer Aided Engineering software, ANSYS Computational Fluid Dynamics Software, Star CCM$^+$ Computational Fluid Dynamics Software, and Artificial Neural Network in MATLAB. The students followed a standard reporting procedure in the department of Mechanical Engineering to present their reports. The reports of their works were evaluated against rubrics for the FYP project. A critical look at the FYP marking criteria aided the development a rubric for determining the level of knowledge construction each students exhibited in their works, thus this paper focused on the two major parts of the thesis report that reflect knowledge construction. With the consideration of knowledge construction, a rubric was developed on methodology presentation as shown in Table 1 and presentation of results with the relevant discussions as shown in Table 2. Following the rubrics, the reports were re-evaluated for knowledge construction.

TABLE 1
LEVEL OF KNOWLEDGE CONSTRUCTION ON FYP RESEARCH METHODOLOGY

Rubrics	*Weightages*				
	1	2	3	4	5
Assumptions and limitations where necessary	No definition of limitation or operating constraints	Incomplete identification of limitation or operating constraints	Complete identification of limitation or operating constraints but lacking coherence	Identification of limitation or operating constraints without a link to the system's physics	Identification of limitation or operating constraints linked to system physics
Theoretical background / Physics of the research area	The investigation method has no physics reflection of the subject area	The investigation method has some underlying physics on subject area but lacks coherence	The investigation method has underlying physics of the subject area but could not identify the specific supporting equations	The investigation method has underlying physics of the subject area but could not connect all physics equations to each of the equation of operation of the system	The investigation method has underlying physics of the subject area and linked all the processes in the research accordingly with the physics
Numerical / Experimental Investigation method/procedures	Presented image of the system without description of the components	Presented image of the system with description of the components but could not substantiate the operation process as related to the investigation	Presented image of the system with description of the components, proper instrumentation but missing link on the real operating process but with good definition of boundary conditions	Presented image of the system with description of the components, proper instrumentation or definition of boundary conditions but lacked sequential arrangement of procedure	Presented image of the system with description of the components, proper instrumentation or definition of boundary conditions and good choice and definition of operating condition/process
Algorithm and software used / Equipment and material used	No identification of software or equipment/materials used	Clear identification of software or equipment/materials used without describing the reason for the choice	Clear identification of software or equipment/materials used with clear reason for the choice of procedure without justification	Clear identification of software or equipment/materials used with clear reason for the choice of procedure with justification but no supporting reference	Clear identification of software or equipment/materials used with clear reason for the choice of procedure with justification and references

TABLE 2:
LEVEL OF KNOWLEDGE CONSTRUCTION FROM FINDINGS

Rubrics	*Weightages*		
	Disagree (0)	Fairly Agree (3)	Agree (5)
Creativity and Innovation			
Evaluation of outcome and judging results			
Assessment of theories or			
Comparison of ideas			
Recommendation			

The rubrics for the result analyses and discussion with possible recommendation in the FYP were evaluated based on the agreement of the knowledge constructed from the project investigation with the underlying physics in the particular project area. The rubrics as shown in Table 2 infers that a student will get zero when there is a disagreement between the reported knowledge and the physics of the study area; the student gets 3 points when the work fairly agrees with the physics which is an indication that the student's report is right but lacks sound knowledge on how best to present the work; while the student earns 5 point when they can present clearly the physics and substantiate findings with reference.

III. FINDINGS ON STUDENTS REPORT ON KNOWLEDGE CONSTRUCTION

a. A. Knowledge Construction on Research Method

The level of application of knowledge construction by the students on their research method was found to be higher with students who employed ICT simulation software compared to students that conducted experiments with reference to the rubrics as presented in Table 1.

The result of the reports review is presented in average as shown in Table 3. The review of the students report showed that the students using ICT simulation software had a lot of reflection on previous studies that they conducted as they had to do a lot of consultations on the use of the software, the application of different models that were embedded in the software and also acquainted themselves with the several assumptions that must be fulfilled to achieve their target. The students that conducted experiments paid little attention to some critical points of limitations necessary in their experiments. One most important constraint that the students that conducted experiments virtually ignored was the ambient temperature in some of their investigations.

TABLE 3:
LEVEL OF AGREEMENT IN KNOWLEDGE CONSTRUCTION ON RESEARCH METHODOLOGY

Rubrics	*10 ICT Based Students*	*8 Experimental Based Students*
	Average Grade by Weight	Average Grade by Weight
Assumptions and limitations where necessary	4.5	3
Theoretical background / Physics of the research area	4	3.5
Numerical/Experimental Investigation method/procedures	4	4
Algorithm and software used / Equipment and material used	4	3.5

b. Knowledge Construction on Output of Investigation

The reports of the students were found impressive such that there was no disagreement between the results and the underlying physics in the various research areas. Considering the average results of the various criteria on the research investigation results as presented in Table 4, it was observed that under the criterion 1 - Creativity and Innovation, the students that used ICT software created a lot of new models and played with various conditions that they could think of to see what could possibly happen under certain circumstance. This is because the cost of simulation is less when compared with experimental investigation. The students that conducted experiments mostly followed experimental procedures and only added few values in the permissible areas which the experimental model permits. Considering criteria 2 and 3 in Table 4, it was found that the students that conducted experiment had higher point which is evident in the method through which they substantiated their claims in the report as they had validation from other experimental works of literature. On the other hand, the students that employed simulation in their investigations developed some knowledge that could only be substantiated or validated using experimental investigations but aligned with the physics of the various research areas. Criterion 4 focused on the critical understanding of the students on the work they have done and the judgmental power to make recommendation on how best to improve the system. On Criterion 4, it was observed that the students that conducted their investigations using ICT simulation software presented higher level of knowledge construction which was due to the various parameters that the students could employ in their simulations thus they have more recommendations in their research that could lead to more investigation and enhance understanding in the research area than what was observed in the reports of the students that conducted their investigations experimentally. The experimentally base project students made recommendations but have lower level of knowledge construction which might be due to few parameters that they could investigate and duration of the experiments.

TABLE 4:
LEVEL OF AGREEMENT IN KNOWLEDGE CONSTRUCTION ON RESEARCH OUTPUT

No.	*Rubrics*	*10 ICT Based Students*	*8 Experimental Based Students*
		Average Grade by Weight	Average Grade by Weight
1	Creativity and Innovation	4.6	3.5
2	Evaluation of outcome and judging results	4.2	4.5
3	Assessment of theories/Comparison of ideas	4.2	4.5
4	Recommendation	4.5	3.5

IV. CONCLUSIONS

The study showed that ICT supports knowledge construction, enhances reflection of students on previous studies and improves the opportunity to expand knowledge and understanding. A comparison between ICT Simulation base project investigation and Experimental Base Project investigation showed that students that used simulation software are more innovative in engineering report and create higher level of knowledge construction than those that conducted experiments. This is because those that conducted simulation study have opportunity to play with several configurations of parameters and boundary conditions which is one limitation in experimental investigation. This study can also relate the engagement of students in Work-integrated Learning (WIL) where they are better prepared for work or professional practice after acquiring higher level of knowledge construction and cognitive skills, not only in their respective disciplines but also in diverse fields

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