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Strategies to Integrate Design Process into TVET in Conducting Final Year Project

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Abstract. Ministry of Education (MOE) has imposed the final year project as a design-based project and the requirement to graduate with vocational diploma. Guideline for final year project becomes the basis to conduct the project executed based on Final Year Project I and II course. To have an effective and standardized teaching and learning (T&L) environment, design process should be implemented in technical and vocational education and training (TVET). Therefore, this paper proposes the strategies to integrate the design process in supervising, report writing, and assessing the final year project complying with the MOE guideline. The design process becomes the backbone due to its capability to sequence the design activities, integrate the various knowledge, and enhance the creativity towards the selection of the final design from a range of designs with their respective conflicting issues. The strategies include integration of the design process into the supervision, report writing, and assessing the course. These strategies will be implemented through workshop, feedback and student activities. Kolej Vokasional Kota Tinggi (KVKT) is selected to be the case study.

1. Introduction

Technical and Vocational Education and Training (TVET) in Malaysia plays pivotal role in providing skilled workers for economic transformation and nation growth. In the 11th Malaysia Plan, 1.3 million additional jobs in Malaysia will require workers with TVET related skills. It is expected that TVET graduates will contribute to the economic growth by fulfilling the demand of industry [1]. Thus, in Malaysia, vocational colleges, community colleges and polytechnics are the institutions which focus in offering TVET module.

Previous study has shown through thinking and reasoning, problem solving, and decision making will able to develop continuous learning process is also applicable to TVET graduates. Reeve believes that building problem solving, and critical thinking skills are important for working in the 21st century [2]. Moreover, student which has been exposed on how to solve problem are better in solving complex problem compare to those who were not [3]. Thus, it is suggested the need for high order thinking in TVET is necessary, since the high order learning is one of the components in creative and critical thinking which can help student to be more innovative and imaginative [4].

Learning higher order thinking skill is needed to help with difficulty of generating ideas which is one of the key factors to be successfully in conducting project-based problem [5]. Yee et al. recommended a model plan which used integrated and self-instructional approach in teaching and learning of high order thinking skill in TVET [6]. However, King et al. [7] disagree with Yee at al. and suggested that learning approach with high order thinking skill required more clear communication from the teachers to improve student's thinking task while reducing confusion and doubts.

In 2007, Gattie and Wicklein reported that 90% of teachers said that engineering design is suitable in technology education [8]. There are also several previous papers mentioned the implementation of the design process in teaching and learning [9–12]. By using the design process, students can improve in analyzing and collect information or data, define problem, generate ideas and solve problem in completing their project. This is in line with TVET program which mainly focuses on practical activities among student. In 2006, Jacobson and Wilensky suggested that complex system thinking should be learned by student at middle school level [13]. They also recommended teaching system thinking in a group learning environment approach. The systematical thinking and engineering design will provide a systematic approach to solve defined problems. Thus, by using the design process and system thinking approach, it can provide better skills in the student. Design process encouraging student to generate ideas and think creatively not only in developing innovative product, but also help in reasoning on daily problem. Thus, the design process is a good approach integrated with final project in TVET module is a part of problem-based learning.

This study focuses on conducting Final Year Project (FYP) for vocational college which FYP is one of the requirements to graduate with vocational diploma. The execution of the FYP in Malaysia is based on the guidelines provided by Ministry of Education. The project can be a product or software or service depending on the nature of the courses. The need to have one approach in conducting the FYP will ensure the standardization in supervising, report writing and assessing the project. Therefore, this paper will outline the strategies to integrate the engineering design process in conducting FYP. Total design approach by Pugh [14] is adopted in this project. Kolej Vokasional Kota Tinggi (KVKT) is selected to be the case study. These strategies will be implemented through workshop to KVKT academic staff, feedback and student activities.

2. Final Year Project (FYP)

The implementation of design based for the final year project is conducted based on two courses; Final Year Project 1 (FYP1) and 2 (FYP2). FYP1 is a two-credit hour course on the third semester, whilst FYP2 with four credit hours is conducted in the fourth semester.

In FYP1, students are required to propose the design. At the end of the semester, oral proposal defense is conducted. The first three chapters of the project report is required to be submitted. Log-book, proposal presentation, and written progress design report are assessed. FYP1 is the prerequisite for FYP2.

FYP2 gives a grace period of one month or four weeks to the students to do amendment on the proposed design if required. Then, the students can proceed with design embodiment prior to fabrication of the prototype. Assessment is based on a project report, oral presentation and prototype.

3. Strategies in Integrating Design Process

Since design requires multidisciplinary activities, problem with managing various activities and knowledge without compromising innovation and creativity is the main issue encountered by the students. Therefore, design process becomes the solution by sequencing the activities, integrating the various knowledge, and enhancing the creativity towards the selection of the final design from a range of designs with their respective conflicting issues. Moreover, the design process is not only be able to sequence the design activities, it also becomes the framework in the writing the design report.

Figure 1 shows the design process. It starts with problem definition, then it follows with information collection. Based on the data analysis from the information gathering, product design specification (PDS) will be outlined. PDS will become the boundaries for the following process onward. Then, a number of concepts will be developed, and it is followed with the selection of the final design. Once the final design is selected, the parts that embodies the design are defined in the final design embodiment stage. Then the prototype is fabricated.

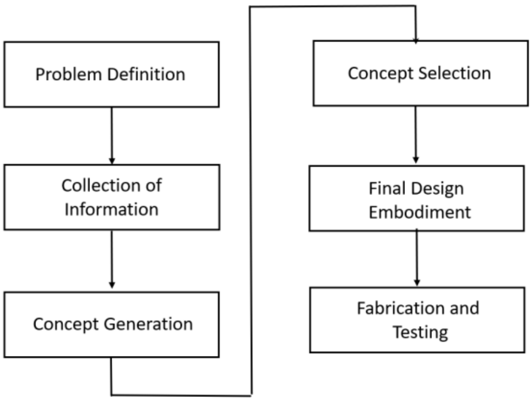


Figure 1. Design Process [14].

Moreover, the T & L approach should be based problem-based approach. Lecture is the main method in T & L and it should be supplemented with studio-based class. Studio-based class is where the students will be coached and guided to handle the project.

Since TVET is hand-on based education, fabrication will be the traits of the graduate, therefore this paper will only focus on strategies from the problem definition to final design embodiment. In the following, it will discuss in detail the strategies to implement the design process in supervision, report writing, and assessment.

4. Strategies in Supervision

Within the same framework of the design process, it can be implemented differently for various level of education depending on the tools used. Due to the background of the students that has little experience in handling design-based project, the proposed design process is structured as such that the students will be guided from one step to another without compromising the innovation and creativity.

4.1. Problem Statement, Information Collection and PDS

The problem statement is the most important stage. The problem statement is structured as the following.

Problem Definition: [*Who*] needs [*What*] because [*Why*].

The '*who*', '*what*' and '*why*' lead to more guided approach in the information collection and PDS stage as elaborated in Table 1.

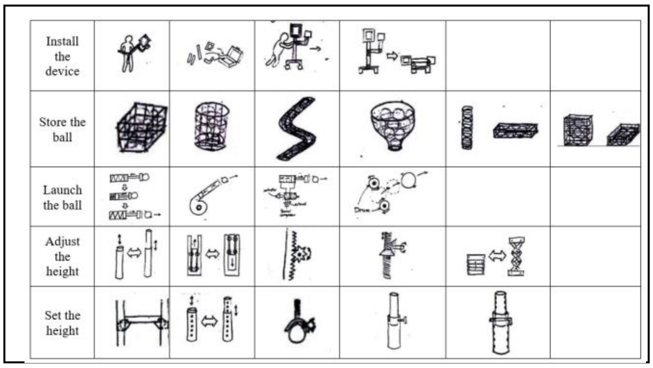
Table 1. Structured relationship between problem definition statement with information collection and PDS.

Problem Statement	*[Who]* needs *[What]* because *[Why]*.		
	Who	What	Why
Collection of information	Target users: to define the user needs via survey, interview, or questionnaires.	Similar product: to comprehend the working principle of the device and its advantages and disadvantages.	Lead to more possible areas for information collection. However, it is recommended to look into standard procedure, field study, and availability of the raw material.
PDS	The human factor that defines spatial specification of the device such as height of the device, reachable area etc.	The specification of the device such volume per day etc	The possible specifications are: The device must comply (state regulation or SOP) The device must able to be fabricated using the available manufacturing processes.

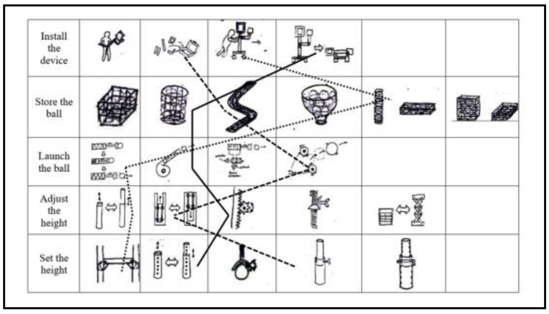
4.2. Conceptual Development

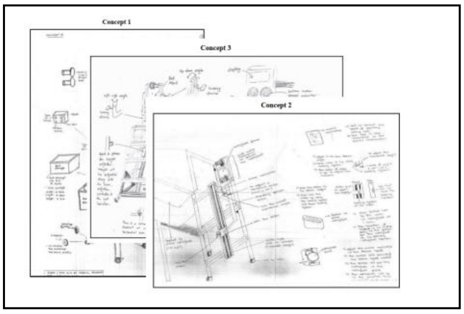
In design, development of as many concepts as possible will be the key factor to ensure the generation of a good final design. There are many methods to develop the concepts. In the case of this project, morphology chart is selected because morphology chart is more structured, and the same time promotes innovation and creativity. Morphology chart helps to generate a complete range of the alternative design solutions by breaking down according to its functions and the students will search the possible solutions based on the functions without thinking the problem as the whole. Understanding of 'what' in the problem definition helps in forming the functions of the device. Sample morphology chart for designing volleyball training device is shown in T 2a.

The solutions or concepts are generated by combining the solution from each function to form the device. The concepts are sketched to create visual forms of the concepts. This concept generation is shown in Figure 2b.



(a) Morphology Chart





(b) Concept Generation

Figure 2. Morphology chart and concept generation.

4.3. Selection of final design and final design embodiment

The major issue in the final concept selection is the conflicting issues in making the decision. To compromise these conflicting issues, selection matrix is adopted. There are two types of selection matrix; screening and scoring. In the case of huge numbers of concepts to be selected, the selection matrix starts with screening first and follows by scoring. Despite of the number of concepts is small, concept screening is preferred to be used as it is less complex than the scoring method. The basis of selection matrix method is to compare the proposed design with the datum based on the specific criterion.

To put emphasis on the criteria of the final design, the percentage of the number of criteria over the total number of the criteria is used as the yardstick to set the priority of certain group of criteria. This is the way to compromise the conflicting issues. One of the concepts or one of the existing similar products is used as the datum. For each criterion, comparison is made between the datum and the concept. '+', '-', or '0' is given if the criterion of the concept is better, worse or equal to the same criterion of the datum. Figure 3 shows the sample of matrix selection.

When the final design is selected, it will be followed with embodiment of the design. The embodiment will detail up to the component level with the aim to have a complete information on the material and dimension of the parts.

5. Strategies in Report Writing

Design process will become the framework for report writing. Table 2 shows the mapping of the design process for report writing complying with MOE guidelines.

Performance		Datum	Concept 1		Concept 2		Concept n
Mobility	Ease to move the machine		+		+		0
	Stability of the machine when in motion		-		+		+
	...		0		-		-
	Smoothness of the movement		+		+		-
Ball Storage	No of steps taken to store the ball		+		0		+
	The reachability of the storage opening		-		0		-
	...						
	The amount of time to store the ball						
...							
Manufacturing / Production		0				...	
Available raw/material from store							
Less number of material to be bought							
Available manufactruing process			...		...		...
Less number of not available manufacturing process							
...							
Aesthetic							
The machine is very attractive							
...							
		Total (+)	5		12		10
		Total (0)	5		6		3
...		Total (-)	15		7		7
		Total Marks	-10		5		3

Figure 3. Sample of Matrix Selection.

6. Strategies in Assessment

Assessment based on the design process can be implemented to ensure the standardization of the assessment throughout all the programs. Table 3 shows the proposed detail of the assessment.

Table 2. Mapping of design process with project report

Design Process	Design Report
Problem Statement	Chapter 1 1.7 Problem Statement
Research Background	Chapter 2 2.1 Human Factors: target users, persona, survey, questionnaires 2.2 Similar Product: working principle, advantages and disadvantages, form and function 2.3 Field Study 2.4 Raw Material 2.5 Standard Procedure … 2.x Product Design Specification
Conceptual Design Concept Selection	Chapter 3 Methodology 3.1 Conceptual Design 3.2 Concept Selection
Initial Embodiment	3.3 Initial Embodiment & Bill of Material 3.4 Costing
Fabrication and Testing	Chapter 4 4.1 Fabrication 4.2 Testing 4.3 Modification
Appendix	A Morphology Chart B Individual Concept C Initial Embodiment

Table 3. Design Based Assessment Method

	Percentage	Detail content	
FYP1 : Design Proposal	60%	Chapter 1 to 3	
		Problem Definition:	5
		Research Background	15
		Product Design Specification	10
		Concept development	10
		Concept Selection	10
		Embodiment, BOM, Costin	10
FYP2: Design Report	45%	Chapter 4 and 5	
		Fabrication of the prototype	20
		Testing the prototype	15
		Modification of the prototype	10

7. Recommendation and Conclusion

These are the strategies to implement design process into TVET FYP. One day workshop will be conducted to all the KVKT academic staff who are supervised FYP students. This workshop will expose the participants with design process and follows with group discussion to specify the contents of each process. At the end of the workshop, participants will finalize the content for each process that are suitable to be implemented. Then, it will be followed by the feedback from participants and by then, the detail of the framework for implementing design process can be finalized and adopted. This framework of design process in TVET will have the pedagogical implication in conducting FYP for vocational diploma students.

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