Smart Plant Management Monitoring System (SPMMS) learning model toward Greening Technical and vocational education and training (TVET) sustainable development

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ABSTRACT – Greening TVET fills gaps in employment sector evolution, trainers' relevant knowledge, current scope and delivery mechanisms, and workforce's adjustment to technological shifts. This paper proposed a learning model of Smart Plant Management Monitoring System (SPMMS) for learners toward greening TVET sustainable development. The learning model, based on Learning Design method, anchoring by ADDIE's model, were comprising the initial setting up, the procedure and the output realms. The model, with the average validation results of the mix from good to very good, was the output of the experimental approach conducted prior to this study. Hence, the model benefits TVET-based relevant stakeholders.

1. INTRODUCTION

1.1 Technical and vocational education and training (TVET)

Technical and vocational education and training (TVET) is defined as education and training which provides knowledge and skills for employment [1]. It utilizes formal and informal learning [2] for equipping youth and adults with the skills deemed necessary for employment, entrepreneurship and lifelong learning.

Greening is regarded as knowledge and practice adaptation processes to align them with the sustainability concept [3]. While Green skills refer to the knowledge, abilities, values and attitudes required to live in, develop and support a sustainable and resource-efficient society [4], Sustainable development is defined as meeting present development's needs without compromising future generation's ability to meet their needs (UNCED, 1987).

A learning model triggers competency-based learning approach which requires modules as teaching materials that students can use. Modules refer to materials for teaching which are systematically written [5,6], practical and directed [7,8] to engage independent learning through students' competencies in knowledge, skills, and work attitudes, reflecting cognitive, psychomotor, and affective domain. Gearing toward an ideal module and adhering to the curriculum demands which requires a competency-based learning process is the ultimate aim [9].

1.2 Smart Plant Management Monitoring System (SPMMS)

Plant Health Management is a technique that identifies and remedies the succession of biotic and abiotic factors that limit plants from reaching their full genetic potential. It includes novel approaches for monitoring the plant's health condition. Certain environmental factors such as soil moisture, light intensity and pH level of water have an impact on the productivity of plant growth, development and yields. In fact, with unpredictable weather conditions, it is difficult to control the temperature and humidity of the soil to ensure plant fertility. Thus, an adequate plant monitoring system is required to give information to users about how the growth of the plant is affected by these factors. This can benefit the user to continuously monitor the plant's health from a remote location without any manual intervention.

Smart plant monitoring has been studied through various applications [10-13]. Among the studies include Automation of Hydroponics Green House Farming using IOT [10,12]; PET Film [11]; Internet of Things (IoT) using LoRa Technology [13]**.** Despite the various studies, literature lacks of learning model for greening skills TVET.

The present study focused on developing a learning model of Smart Plant Management Monitoring System (SPMMS) for learners toward greening TVET sustainable development. Learning design pillared by ADDIE's model were utilized. The model comprises the initial setting up, the procedure and the output realms.

2. METHODOLOGY

2.1 Method

Learning design and focus group interview are the methods used to enable designers to produce learning activities and interventions, by utilizing appropriate pedagogical realms, resources, technologies and quality feedback.

2.2 Theoretical Framework

Learning design and ADDIE's instructional Design Model pillar the study. Learning Design principle focuses on more explicit and shareable design process. Learning

design integrates empirical evidence to understand the design process with a range of learning design resource development, tools and activities [14,15]. Taking ADDIE's model, a learning design comprised the following phases shown in Table 1.

Table 1: ADDIE Instructional Design Model

The Analysis Phase	Analysing the needs and constraints, learning environments, learning objectives,new skills and the learners' current level. (Interview with experts).
The Design Phase	Outlining strategies/blueprint to reach the instructional goals; content, subject matter experts, user experience, assignments, tests, graphics and media. (Interview and Content Analysis Method).
The Development Phase	Creating the course which is aligned with the blueprint from the Design Phase.
The Implementation Phase	Implementing the course.
The Evaluation Phase	Measuring the effectiveness and efficiency of the training. Formative and summative approaches are used.

2.3 Procedure

In the present study, two documents were utilized namely ADDIE instructional design model [16] and the Smart Plan Monitoring Modules. Modules were later analyzed to match the ADDIE model. The modules were analyzed in terms of the Learning Outcomes, Learner Analysis, Student Learning Time and Assignment Analysis.

The focus group engenders continuous ideas where a moderator leads the discussion. The group comprises 7-10 selected members and discussion sessions on a given topic can take about 1 to 2 hours to accomplish the objectives of the discussion. The focus group consisted of 10 researchers cum lecturers, having experience in environmental studies and plant management system. In terms of demography, they comprised 4 female and 6 male lecturers. In terms of teaching experience, all ten lecturers have been teaching for more than 10 years.

The focus group interview sessions were held three times to gain feedback and improve the framework. The interview sessions were held in the early January, late February and early March. The duration was 4 hours per session.

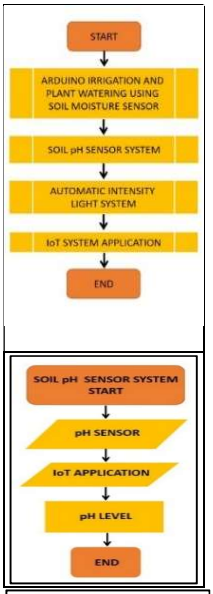
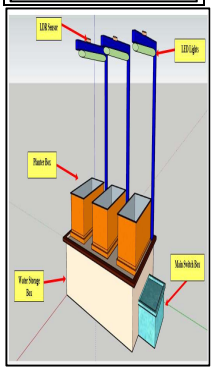
3.0 RESULTS AND DISCUSSION

3.1 The learning model of SPMMS

The focus group reached a consensus on the phases. Phase 1 focused on the Analysis stage regarding Learning Outcomes (LO), Learner Analysis (LA), Student Learning Time (SLT) and Assignment Analysis (AA) with the respective activities. Phase 2 highlighted Design and Development in terms of strategies, Content Development and respective activities. A discussion on the prototype of the learning model was also held. Phase 3 focused on the implementation and Evaluation.

Table 2 and Figure 1 show the Infographic of SPMMS procedure and the proposed learning model of Smart Plant Management Monitoring System (SPMMS) respectively.

Table 2 Infographics of SPMMS procedure

PH	**Learning Model of SPMMS**	**Activities**
Analysis	LO LA SLT AA	Phase I Discussion on LO, LA, SLT, AA
Design & Development		Phase II i.Component & Functions ii.Sensors iii.Working Principles
Implementation & Evaluation		Phase III i.Circuit Simulation ii. Practical Application (Planter Box): *Brazilian Spinach Chilli Plants Min Coeur Roses* iii.Gathering Data & Monitoring

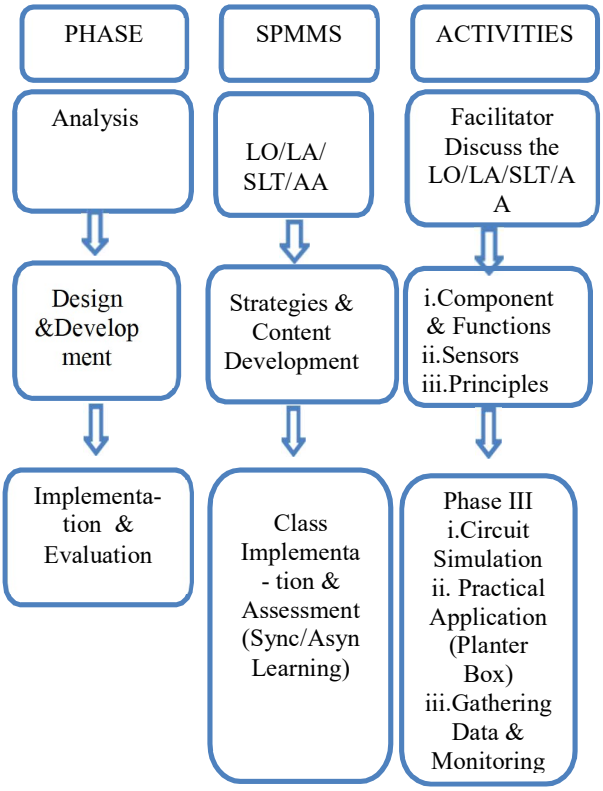


Figure 1 The proposed SPMMS learning model

3.2 Discussion

The learning Model

The learning model of SPPMS comprises 3 phases Analysis, Design & Development and Implementation & Evaluation.

The analysis phase focuses on the development of Learning outcomes, Learner analysis, Student Learning Time and Assignment Analysis. The LOs reflect the targeted competency in the implementation phase namely the identification and comprehension of components and their functions. For example, identify the components of SMPPS and their functions (LDR Sensor, soil sensor and others).

SLT is subject to the course requirement whereas Assignment analysis include types of assignments to be measured. It is advisable to include measurements on a project of the planter box, circuit simulation and data through plant monitoring. The devices are intelligently linked together which enables to produce a new form of communication.

The design and development phase is the phase where the components and processes used in the model are highlighted which include components and functions, sensors and their roles and working principles of Plant management system.

The implementation and Evaluation phase refers to the ways in which learners experience the actual plant management procedure through the planter box where they choose the type of plant and are to utilize the sensors to ascertain the plant condition in terms of appropriate level of soil moisture and light intensity. Then they are exposed to the gathering and monitoring data through the IOT. The mobile App system is illustrated in Figure 2.

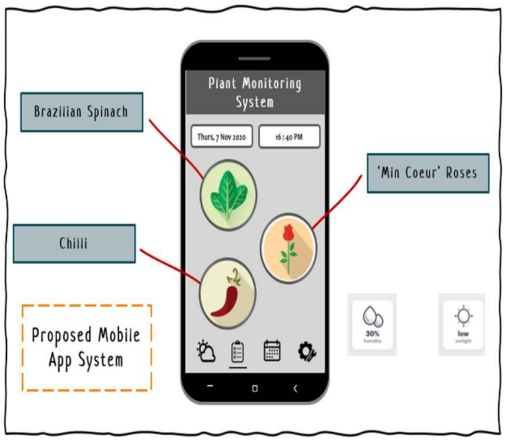


Figure 2 The proposed Mobile App system

The evaluation involves students/ feedback on the process. This can be captured by keeping a blog. The evaluation is also conducted through feedback from the experts. Lecturers provide feedback continuously to ensure students are always on the right track through questioning throughout the process. Rubrics are designed clearly and concisely to guide students in their task completion.

This learning model is in tandem with Learning Design principle which focuses on more explicit and shareable design process. It is also in rhyme with other studies which asserted that Learning design integrates empirical evidence to understand the design process with a range of learning design resource development, tools and activities [14,15].

Focus Group Session

The Analysis stage in terms of LOs and LA does not present any problem to the participants. The problems exist when they look into the Student Learning Time as they are not sure the number of hours to be allocated for outside class activities. The problem was resolved when they had the information from the Head of Department, explaining the hours that students are permitted to perform. Respondent 2,3,7 and 10 commented on certain words that seem to be too complex for students to understand. They hoped that simpler terms and user-friendly approach can be included. All respondents agreed in unison that concrete examples should be added to ease students' understanding on the processes. Respondent 1 stated that important words should be highlighted in bold. Respondents 8 and 9 loved the infographics with great, bright complementary colors. The session lasted for three hours and after several modification and meetings, a finalized learning model has been produced.

4.0 CONCLUSION

In conclusion, this paper has proposed a learning model of Smart Plant Management Monitoring System (SPMMS) for learners toward greening TVET sustainable development. The learning model, based on Learning Design method, anchoring by ADDIE's model, include the initial setting up, the procedure and the output realms. The model has undergone several evaluation

series with the average validation results of good to very good. Hence, the model is beneficial for TVET-based relevant stakeholders and is novel in the Malaysian context, for thus far, TVET in Malaysia has not implemented any module for Plant management. Future study should focus on the implementation of this model in classroom.

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