# ASSURing Science Learners' Participation in STEM Education: Exemplary Physics Lesson to Promote TVET

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## Abstract

**Purpose and Research Question** - Learners' active participation in STEM education has become an important factor in student-centred learning environment. '**A**nalyzing' learner characteristics by '**S**tating' objectives can assist science educators to '**S**elect', modify or design and '**U**tilize' materials suitable for classroom teaching and learning activities. This article illustrates an exemplary Physics lesson developed through ASSURE instructional model to promote 'Technical & Vocational Education and Training' (TVET) as part of bigger scale project-based programmes '**R**equiring' learners' responses in their STEM-based learning experience integrating Arts/reading/culture with '**E**valuation' of their learning outcome or project output.

**Methodology** – In this qualitative study, ASSURE instructional model is used as guide to develop modular approach of STEM-based learning exemplar to study Physics concepts such as Pascal's principle, hydraulic system, pressure transmitted in an enclosed fluid, to name a few with evidences of output illustrated through 'Within- and/or Exemplary-Case Analysis'. The learning output of the secondary students guided by teachers (who are the first and second co-authors of this paper) were submitted to the '' (LearnT-SMArET)(2021-22) e-course series, a platform initiated by the third author to promote project-based programme since 2018. The projects prepared by students were submitted for evaluation using the Rubric designed as alternative assessment for LearnT-SMArET programme under the category of 'Technical & Vocational Education and Training integrating Entrepreneurship Education' (TecVoTEE) that is one of the most recently initiated sub-theme under the 'Learning Science and Mathematics Together in a Borderless World' [LeSMaT(Borderless)] 'Basic Education and Student Networking' activities to fulfil SEAMEO Education Agenda Priority Area No. 5 (Revitalising teacher education) and No. 7 (Adopting a 21$^{st}$-Century Curriculum)(SEAMEO, 2018) as well as Sustainable Development Goals (SDGs) No. 4 (Quality education) and No. 17 (Partnership in achieving goals) (UN, n.d.).

**Findings** – The data revealed the following qualitative findings from observation, interview and document analysis: (1) Students were able to prepare project output related to TVET, one of which is entitled 'Pascal's principle by using a hydraulic lift as an example'. (2) Project team members had developed self-directed/paced/accessed learning with enhanced interest and competency to showcase learning output related to STEM integrating **A**rts-language-culture (STEAM) education. For example, they were able to verbalize their learning experience with write-up of reflective journals that could be extracted for module writing by the authors of this paper.

**Significance and Contribution in Line with Philosophy of LSM Journal -**

This papers contributes by illustrating secondary science learners' active participation following the modular approach of STEM-based learning exemplar to study Physics concepts. The exemplar case presented suggested that considering learners' capability and their motivation level to participate actively in the science classroom could better ASSURE the achievement of governmental aspirations to promote TVET education in line with global trends to prepare 'Future-Ready' workers towards the Industrial Revolution (IR) eras.

***Keywords:*** ASSURE instructional model; Pascal's principle; Hydraulic lift; TVET education; LearnT-SMArET; LeSMaT(Borderless)

## Introduction

### Background and Overview

Learners' active participation in STEM education has become an important factor in student-centred learning environment. '**A**nalyzing' learner characteristics by '**S**tating' objectives can assist science educators to '**S**elect', modify or design and '**U**tilize' materials suitable for classroom teaching and learning activities. This article illustrates an exemplary Physics lesson developed through ASSURE instructional model to promote 'Technical & Vocational Education and Training' (TVET) as part of bigger scale project-based programmes '**R**equiring' learners' responses in their STEM-based learning experience integrating Arts and reading/culture with '**E**valuation' of their learning outcome or project output.

### Rationale and Research Objectives

This project aims to explain Pascal's Principle by using a hydraulic lift as an example.

The objectives of this lesson exemplar include:

- To demonstrate how pressure transmits in an enclosed fluid.
- To study how the air space in hydraulic system affects the effectiveness of the system.

## Literature Review

### Theories and Models to Promote Technology-enhanced Student-Centred Learning

Review of literature is made on various theories and models that promote student-centred learning supported by the emerging technologies. Among the examples include research anchored on social constructivist and socio-cultural framework integrating digital tools (e.g. Alizah, et al., 2019; Ng et al., 2020), use of 'Design and Development Research' (DDR) (Jiea, et al, 2020; Richey & Klein, 2014) and 'Attention, Relevance, Confidence, Satisfaction' (ARCS) (Narulita,et al., 2018) model in research and development (R&D) activities, 'Analysis, Design, Development, Implementation and Evaluation' (ADDIE) framework (Ozdilek & Robeck, 2009) and ASSURE (Kurt, 2015) instructional design models.

Exemplary technology-enhanced student-centred learning activities anchored on constructivist learning theories were reported Chia et al. in Ng et al. (2023) reported the 5Es constructivist model to plan Physics lesson ideas involving '(1) Students' engagement in project-based activities to activate prior knowledge by making connections between Pascal's Principle and hydraulic lift' (**E**ngage); (2) Project team members conducted hands-on activities to explore the concept of Pascal's Principle (**E**xplore); (3) After exploration, they shared their experience with explanation on the hydraulic phenomenon (**E**xplain); (4) They were provided with opportunities to expand their knowledge of Pascal's Principle and apply the hydraulic system into hydraulic lift (**E**laborate); as well as (5) Finally they reviewed and reflected on their own learning and new understanding through the building hydraulic lift prototype for evaluation and modification based on feedback from experts (**E**valuate).

### ASSURE Instructional Design Model

As aforementioned, '**A**nalyze learner characteristics, **S**tate objectives, **S**elect, modify or design materials, **U**tilize materials, **R**equire learner response and **E**valuation' (ASSURE) (Kurt, 2015)(Figure 1) is one of the instructional design models anchored on social constructivist theories recently given attention by educators and curriculum developers with research evidences published by Abdullah (2015), Bavli and Erisen (2015), to name a few.

Figure 1 ASSURE instructional design model


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In this qualitative study involving observation, interview and document analysis (Creswell, 2009), ASSURE instructional model is used as guide to develop modular approach of STEM-based learning exemplar to study Physics concepts such as Pascal's principle, hydraulic system, pressure transmitted in an enclosed fluid, to name a few with evidences of output illustrated through 'Within- and/or Exemplary-Case Analysis' (Yin, 2014). The learning output of the secondary students guided by teachers (who are the first and second co-authors of this paper) were submitted to the '' (LearnT-SMArET)(2021-22) e-course series, a platform initiated by the third author to promote project-based programme since 2018. The projects prepared by students were submitted for evaluation using the Rubric designed as alternative assessment for LearnT-SMArET programme under the category of 'Technical & Vocational Education and Training integrating Entrepreneurship Education' (TecVoTEE) that is one of the most recently initiated sub-theme under the 'Learning Science and Mathematics Together in a Borderless World' [LeSMaT(Borderless)] 'Basic Education and Student Networking' activities to fulfil SEAMEO Education Agenda Priority Area No. 5 (Revitalising teacher education) and No. 7 (Adopting a 21st-Century Curriculum)(SEAMEO, 2018) as well as Sustainable Development Goals (SDGs) No. 4 (Quality education) and No. 17 (Partnership in achieving goals) (UN, n.d.).

The following Table 1 is the brief plan for the lesson exemplar to be implemented.

Table 1 Brief planning for implementation of lesson exemplar.

| | |
|---|---|
| Venue: | Sekolah Menengah Kebangsaan (SMK) Notre Dame, Malacca, Malaysia |
| Type of teaching and learning activities: | Face-to-Face and online (Blended-mode) |
| Year/class: | Form 5S1 |
| Subject: | Physics |
| Theme: | Newtonian Mechanics |
| Topic: | Pascal's Principle |
| Day/date: | Friday, 21st April 2023 |
| Time allocation: | 9am - 10am (1 hour) |
| No. of students: | 23 students |
| Students' ability: | Mixed ability students (One marginalized student from B40 group) |
| Learning competency | Able to build a simple and functional hydraulic lift with elaboration or scientific communication anchoring on Pascal's Principle |
| Expected Learning Outcomes and/or Project Output | At the end of the lesson, students should be able to:<br>• Examine the basic concept of 'pressure' with illustration on its transmission in an enclosed fluid;<br>• Comprehend the function of hydraulic lift and Principle's principle;<br>• Build a simple prototype of hydraulic lift with demonstration on how the air space in hydraulic system affects the effectiveness of the system;<br>• Sketch a complete diagram with the correct components and symbols;<br>• Implement technology-enhanced learning activities using various digital tools. |
| Content | This lesson was conducted to introduce the concept of 'pressure and Pascal's Principle' through blended-mode activities including video viewing ad hands-on session to build prototype on hydraulic lift. |

| | |
|---|---|
| Guidebook or learning resources | • KSSM curriculum standard/guide by Ministry of Education (MoE) Malaysia<br>• Physics Form Five |
| Other learning/ multimedia resources and audio-visual aids (AVA) | • Balloon, Syringe, video clips illustrating robotic lift crane, to name a few.<br>• Assessment observation sheets (rubric)<br>• Vertable (interactive whiteboard)<br>• Notebook/iPads with good Internet connection / Teacher's wifi hotspot<br>• Audio-Visual Aids (AVA) including LCD project, speakers<br>• Web-based resources:<br>How to Make Hydraulic Powered Robotic Lift Crane From Cardboard<br>https://en.wikipedia.org/wiki/Pascal%27s_law |
| Learning model & pedagogy /strategy | ASSURE Instructional Design Model supported by social constructivist and active learning as well as multiple intelligence (MI) theories that can be integrated in any Phase/Stage of ASSURE model (refer Table 2) |

## Analysis and Discussion

This section analyses data collected from the try-out of the abovementioned planned lesson exemplar. The following Table 2 summarizes the lesson steps or stages including teacher's role and student's activity in each Stage/Phase using ASSURE instructional design model.

Table 2 ASSURE Lesson Steps/Stages including Teacher's Role and Student's Activity.

| Lesson Step | Teacher's Role during the Stage/Phase | Student's Activity/Activities |
|---|---|---|
| Analyze Learner Characte-ristics | Teacher implements the following:<br>* Identifying prior knowledge of learners using concept mapping tool (supported by ICT)<br>* Examining the interest/passion of learners<br>* Assessing the learners' attitudes/motivation and competency levels through e-survey(s) | Sample Activities<br>* Responding to brainstorming to understand 'pressure' concept<br>* Answering e-survey(s) to demonstrate attitudes/interest and various competency level(s) |
| State Objectives | Teacher informs learning objectives as below:<br>*To demonstrate how pressure transmits in an enclosed fluid.<br>*To study how the air space in hydraulic system affects the effectiveness of the system. | Sample Activities<br>*Use a blown balloon to demonstrate Pascal's Principle.<br>* Use a simple syringe hydraulic system as demonstration. |
| Select, Modify or Design Materials | Teacher discusses the following:<br>* Use visuals e.g. pictures and videos to retain info. during presentation (MI Visual/Spatial)<br>* Leverage on resources available optimally | Sample Resources Selected:<br>* Audio-Visual Aids<br>* Pictures and Videos<br>* Web-based resources |
| Utilize Materials | Teacher facilitates the following:<br>*Guide to utilize proper material to handle objects skillfully to build hydraulic lift model [Bodily/Kinesthetic Multiple Intelligece (MI)]. | Sample Materials Used:<br>* Balloon, Syringe<br>* Notebook or iPad with wifi or Internet connection |
| Require Learner Response (Rsp) | Teacher raises the following skills required:<br>*Using words and proper language to develop ideas via presentation (MI Verbal/Linguistic)<br>*Creating group chat social learning platforms to elicit learner's response so that project efficiency can be improved and more project team's collaboration can be increased with sharing of information and opinions. | Sample Expected Response (Rsp) Question (Q)<br>(Expected Rsp) Able to verbalize learning experience with write-up of reflective journals that could be extracted for module writing. |

| | | |
|---|---|---|
| Evaluation | Teacher conducts communication channels via:<br>*Interactive discussion & evaluation through<br>verbal (e.g. speaking, writing) and non-verbal (e.g. body language)(MI Interpersonal) acts.<br>*Observation rubric to be prepared to evaluate project team learning output. | Sample Assessment/Evaluation Question (Q)<br>(Expected Rsp) Interactive discussion taking into account views from peer evaluation and feedback from teachers. |

The analysis of data collected also revealed the following qualitative findings from observation, interview and document analysis:

(1) Students were able to prepare project output related to TVET, one of which is entitled 'Pascal's principle by using a hydraulic lift as an example'.

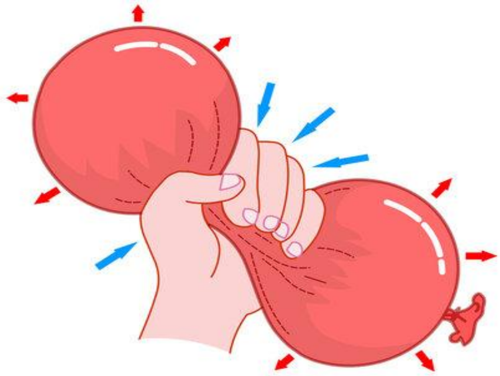
(2) Project team members had developed self-directed/paced/accessed learning skills with enhanced interest and competency to showcase learning output related to STEM integrating **A**rts-language-culture (STEAM) education ~~and **R**eading~~. For example, 'Hydraulic Lift Model Making' by Chong et al. (2023) and 'YEA Model of Hydraulic Braking System' by Cho et al. (2023).

The following are suggested classroom or enrichment activities:

1. Use a blown balloon to demonstrate Pascal's Principle (Figure 2).
2. Use a simple syringe to demonstrate hydraulic system (Figure 3).

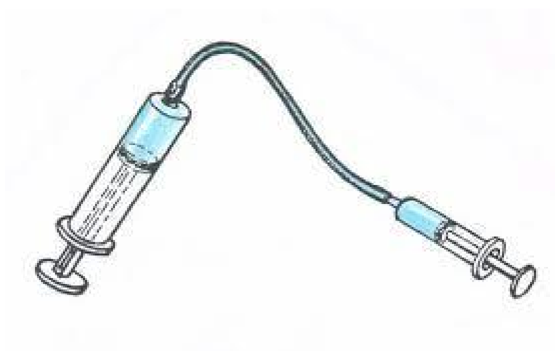
***1. Use a blown balloon to demonstrate Pascal's Principle***

Figure 2 Illustration on how pressure transmit in an enclosed fluid using balloon



***2. Use a simple syringe to demonstrate hydraulic system***

Figure 3 Illustration on how pressure transmit in an enclosed fluid using simple syringe



**Objective 1:** To compare the two different forces applied and produced

*Precautions:*

1. This syringe hydraulic system should include two different diameter's syringes
2. The air space in the syringe must be completely removed

**Objective 2:** To study how the air space in the hydraulic system affects the effectiveness of the system

*Method:* Prepare one set of simple syringe hydraulic systems with no air space and another with air space.

*Observation:* The extended length of output syringe of system with no air space is longer than system with air space.

**Sample Question (Q) and Answer (A)**

1. Why is an incompressible fluid used in hydraulic system?

   ***Suggested Answer:*** Compressible fluid's volume may decrease when a high pressure is acted on it. This may cause servo failure, efficiency loss to the hydraulic system due to the loss of system pressure

2. Why there cannot be air space in hydraulic system?

   ***Suggested Answer:*** Air in a hydraulic system may decrease the precision of the hydraulic system. The larger the amount of free or entrained air, the spongier (less stiff) the system

## Conclusion

This papers contributes by illustrating secondary science learners' active participation following the modular approach of STEM-based learning exemplar to study Physics concepts.

**Summary and Implications**

The pedagogical approaches introduced through ASSURE instructional design model will contribute significantly to the growth and development of learners' attitudes/interest/motivation and competency levels in STEM education. For example, various active learning activities introduced in this article promote higher order thinking skills such as application of knowledge, analysis and synthesis. The participating students learn best when they are actively involved in the learning process. Performing a presentation engages them in deep rather than surface learning also enables them to apply and transfer knowledge better. In science learning, visuals or diagrams effectively help them to learn the principles behind phenomena. Diagrams and demonstrations that are used to explain phenomena help to better understand the principles of the phenomena correctly and integrate their knowledge effectively. Therefore, they would have gained the opportunity to solve the problem collaboratively after the explanation that had been provided, thereafter apply the knowledge to create new ideas.

The learning objectives and expected outcome are also in line with SEAMEO's priority areas No. 7 as well as the fourth Sustainable Development Goal (abbreviated as SDG4) which is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all to promote sustainable living as advocated by Ng et al. (2013). 'Hydraulic lift model making' project has completed one of the objectives of SDG which is technology integration by using the online learning resources to demonstrate physics principle from natural phenomenon. After reviewing and collecting data, participating student project team members explained and summarized Pascal's Principle by choosing a related hydraulic lift as a study topic.

**Limitation, Significance and Future Direction to Promote TVET education**

Due to constraints faced in terms from time and resources available, only one school was selected as sample to try-out the exemplary lesson ideas developed through ASSURE instructional design model. However the case exemplar presented suggested that considering learners' capability and their motivation level to participate actively in the science classroom could better ASSURE the achievement of governmental aspirations to promote TVET integrating transdisciplinary education as advocated by Ng (2017) in line with global trends to prepare 'Future-Ready' workers towards the Industrial Revolution (IR) eras.

The following are suggestions for further R&D related studies to promote TVET education:

1. Further studies should include more schools as sample to explore lessons ideas in physics such as Pressure and Depth (Hydrostatic pressure variation with depth) using ASSURE instructional design model that has proven to be effective in fostering students centered learning.
2. A combination of qualitative and quantitative methods can be employed to gather empirical evidence on a STEM-focused learning module for studying Physics and other STEAM concepts with monitoring/evaluation tools/survey questionnaires such as Fluid Intelligence Test (Ng et al., 2010). This approach can serve as a foundation for advancing TVET as part of STEM education as also researched by Umar (2019).
3. The use of constructivist model as an instructional framework in science education is further encouraged in future studies as the model is designed to promote active learning, critical thinking, conceptual understanding in particular (physics concepts) by engaging students in series of interconnected stages.
4. The use of other instructional models such as SMART, SAM and PBL are encouraged for further studies related TVET education since the models focused on solving real-world problems.
5. The use of technology such as simulations, virtual labs, interactive multimedia and online platforms should be explored more to enhance learners participation and understanding in physics lessons. By integrating technology into TVET settings, students will be provided with hands on experience, facilitate problem-solving and promote engagement.

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