INFUSING PRINCIPLES OF LEARNER-CENTRED LEARNING INTO COURSEWARE DEVELOPMENT FOR THE TEACHING AND LEARNING OF ELECTRICAL TECHNOLOGY

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Abstract

Various blends of pedagogical strategies and technological affordances have been proposed for the 21st century learners commonly known as the Net Gen, Gen Y, or Digital Natives. At Ngee Ann Polytechnic, we have approached Interactive and Digital Media (IDM) courseware development with a sound learning design that is infused with Learner-Centered-Learning features.

This paper reviews the major elements of our journey focusing on the development of learning design leveraging on technology to enhance teaching and learning with a specific focus and application on the teaching & learning of Electrical Technology for the School of Engineering. The paper also describes the courseware, virtual simulation and interactive game developed for this Electrical Technology module.

Keywords

e-learning courseware development, learner-centred learning, electrical technology

1. INTRODUCTION

This paper aims to discuss principles that form the foundation of the Learner-centred approach, and to describe an e-learning courseware project that was designed, custom developed and employed in Ngee Ann Polytechnic's School of Engineering, Electrical Engineering Division based on these principles.

In traditionalistic approaches to education, the responsibility of communicating course material is vested with the instructors. In recent times, more flexible, learner-centered teaching methods have been promulgated, inspired by the concepts of "discovery" learning (Bruner, 1966; Hermann,1969) and "active" or "autonomous" learning (e.g. Johnson & Smith, 1991). These instructional approaches advocate replacing or complementing traditional lectures with active experiential learning such as role-playing, simulations, self-paced or team-based exercises. While these methods have been successfully established in many educational settings, their benefits have not been automatic and have been realized only through substantial effort.

In tandem, the e-learning space has witnessed a correspondingly similar progression. Like traditional classroom instruction, e-learning derives from computer-based instruction paradigms that are geared to reflect passive training approaches. In recent times, more flexible, student-centred classroom teaching methods have been

advocated based on the precepts of 'participatory' and "active" learning; learner-centred approaches are likewise encouraged in the development of e-learning applications. Nevertheless, many e-learning courseware that employ sophisticated multimedia elements in which students interact with simulations, and animations still fail to fulfil their expected educational potential. Thus, adoption of IDM-based features may give the perception of engaging a learner in more active forms of learning, but its use per se does not necessarily ensure attainment of desired learning outcomes. As Michael Allen (2002) acutely observes in an article advocating discovery-based e-learning: "Lurking behind many of today's slick delivery systems are shop-worn, passive learning paradigms that Socrates spurned in the fifth century B.C."

2. LEARNER-CENTRED LEARNING

Learner-centred Learning appears to associate primarily to the constructivist view of learning in placing the importance on activity, discovery and independent learning.

This paper draws on the thinking of Weimer (2002) who is concerned with learner-centred teaching as an exercise in changing teaching practice. Specifically, Weimer identifies learner-centred teaching as encompassing the following five changes to practice:

- Shifting the balance of classroom power from teacher to student;
- Designing content as a means to building knowledge rather than a 'knowledge end' in itself;
- Positioning the teacher as a facilitator and contributor, rather than director and source of knowledge;
- Shifting responsibility for learning from teacher to learner; and
- Promoting learning through effective assessment

In approaching courseware development in Ngee Ann Polytechnic, we seek to evolve teaching practice as highlighted by Weiner (2002) by focusing on four key elements of the learning experience:

- **Reflective focus**

  Through reflective practice, our students are engaged to examine and interpret experiences to attain new understanding. Students will be encouraged to take ownership of their learning and be motivated to think deeper at their learning.

- **Collaborative focus**

  The collaborative focus aligns with constructivist and socio-cultural models of learning which recognize that students' perspectives and prior understandings are important, that context is essential, and that learning is a social activity. A collaborative approach to learning includes the ways in which IDM technologies enable our students to contribute in diverse ways to individual and shared learning goals. Through blogs, wikis, games, social networking sites and other platforms, our students are encouraged to participate in virtual communities where ideas are shared, discussed, cross-fertilized, peer-reviewed etc. The intent is to bring our students together to aggregate ideas, perspectives, insights, experiences.

- **Exploratory (Research) focus**

  Creating opportunities for our students to learn independently through research and self-discovery is fundamental to learner-centred constructivist pedagogy.

  For students to benefit from such opportunities, it is imperative to cultivate a culture of inductive learning and to equip them with suitable strategies. It is hoped that our students will be empowered as knowledge producers through meaningful research and discovery.

- **Doing/Producing focus**

  Doing/Producing relates to providing opportunities for our students to work on meaningful, realistic projects as well as implementing a variety of interactive problems for practice, exercises and tests that aid understanding. This is in recognition that students learn most effectively by doing and producing, rather than by being passive recipients.

  By putting students in control, it places the onus on them to actively engage in the tasks of searching, making the decisions, interacting with technology, contributing to discussion forums and tackling real world issues.

3. APPROACH

3.1 Focus on Learning Design

This phase focuses on articulating the existing learning design of the module and formulating a proposed learning design for development – which incorporates learner-centred learning principles. The front-end analysis will shape the instructional strategies and methods to be adopted, ranging from direct instruction, indirect instruction, experiential learning, independent study and interactive instruction. The outcome of the learning design review will inform decisions on the selection of multimedia and choice of courseware types.

It is reckoned that quality learning outcomes are best achieved with the considered application of pedagogy to the design of the e-learning courseware as well as to the management of the instructional process that revolves around the use of the courseware.

Courseware should not merely be used as an isolated teaching/learning resource; rather, it should also bring with it strategies for use. Consequently, we advocate that due attention be channelled not only to the design and development of content but also to the wider embedding context within which the courseware will be deployed.

3.2 Deepening the Learner-Centred Experience

Learning is often presented in the dualism of either learner-centred learning or teacher-centred learning. In the reality of practice, the situation is less distinct.

A more purposeful representation of learner-centred learning is to interpret these terms as either end of a continuum as shown below:

Learner-centred and Teacher-centred Continuum	
Teacher-centred Learning	**Learner-centred Learning**
Low levels of learner empowerment	High levels of learner empowerment
Learner is passive	Learner is active
Control and ownership with the teacher	Control and ownership with the learner
	

In reviewing how we might look at this in practice, it is efficacious to reflect how far up the continuum we are able to move within contextual barriers in the teaching and learning situation. The following sections articulate possible instructional ideas and pedagogical methods to aid the progression towards a deeper Learner-centred Learning experience.

- **Implications for curriculum and lesson design**

  In relation to curriculum design, learner-centredness acknowledges the precept that students have an element of empowerment and choice in what to study and how to study. A popular learner-centred approach to curriculum design - Problem-Based Learning (PBL), allows for some scope of flexibility within a programme of areas that students may learn. As part of a learner-centred approach, it enables students to define a measure of their own learning parameters in terms of objectives/outcomes, dependent on prior knowledge (O'Neill, McMahon). This element of student choice or control aligns with the principles of learner-centred learning.

  An emergent practice in learning design is the 'democratic' negotiation and formulating of learning outcomes/objectives focusing on what a learner will be able to do (process and competence) vis-à-vis on the content being covered by the lecturer. Where possible, students also have the flexibility to adapt their own learning issues and context. This practice exemplifies the evolvement towards Learner-centred Learning in curriculum design and shifts the ownership of learning to the learner as opposed to a coverage model by the lecturer.

- **Implications for teaching and learning methods**

  To adopt a Learner-centred Learning approach, lecturers should endeavour to actively engage students in acquiring knowledge and skills through exercises in class, fieldwork and use of games and simulations. It is also crucial that students are made more aware of what they are doing and why they are doing it during the learning process. There should also be a strong focus on interaction, such as the use of simulations, discussion forums and synchronous virtual classrooms. Other approaches geared to Learner-centred Learning include devoting due consideration and discussion to prior learning i.e. addressing the needs of students who may be at different starting points. Negotiation regarding learning activities between lecturer and learners will further engage and challenge students.

- **Implications for student assessment practices**

  An important element of Learner-centred Learning is the concept of self and peer-assessment as an essential activity to help students 'take responsibility and ownership for their learning'. It is also advocated that formative assessments be utilized, which emphasizes feedback to students on their learning journeys. The inclusion of more formative assessment encourages a deeper learner-centred approach - whereby formative assessments are embedded in the learning design to help inject a sense of focus for students by highlighting learning gaps which could be addressed.

4. APPLICATION

4.1 Context

In this section, we present a reflective case study analysis of an attempt to develop IDM e-learning courseware with the introduction of learning design considerations and Learner-centred Learning focus for the Electrical Technology module from the School of Engineering's (SoE) Common Programme. The SoE Common Programme was identified as a pilot project under the polytechnic's institution-wide courseware development initiative. The pedagogical challenge was to leverage on courseware to re-orientate from a teacher centred didactic approach towards a Learner-centred Learning direction featuring collaborative, reflective and exploratory learning experiences.

4.2 Background on Engineering Common Programme

The Engineering Common Programme offered by SoE seeks to provide students with a firm foundation and an initial understanding of engineering and career options to assist them in identifying the engineering discipline with the right fit. The Electrical Technology module under the Engineering Common Programme aims to equip students with the necessary foundation for electrical circuit analysis, whereby they will learn electrical theorems and techniques for analysing and solving direct and alternating current circuit problems. Hands-on activities in laboratories will equip them with basic electrical measurement skills and reinforce concepts learnt in lectures and tutorials.

4.3 Review of Learning Design

Upon selection of the Electrical Technology module, an iterative consultation and review process was initiated between the iMedia Centre, Teaching and Learning Centre and module leader Mdm Liang Shi Ping. The intent is to articulate the existing learning design and formulate a proposed learning design for development. Excerpts are outlined as follows:

- **Current Learning Design**
  - Traditional learning design based on lectures, tutorials and lab sessions
  - Lecture notes are used to teach the basic concepts of content
  - During the tutorials, students apply the concept in solving questions

- During the lab sessions, circuits are connected and measurements are taken to validate the theories

- **Summary of Proposed Learning Design**

  - Designed to enable learners to do self-learning on selected topics. Learners will then form groups and undertake reflections and class presentation of applications that arise from concepts learnt
  - Interactive tutorials that help students understand the lecture content, followed by students setting their own questions for others to solve
  - Virtual lab that allows measurement of resistance and voltage. Students to also write their own lab sheets.

- **Proposed Courseware Design Features**

  Courseware

Learning Activity	**Learner-centred Learning Features**
• Self learning on a media rich courseware platform for two topics, namely Electromagnetism and AC circuit analysis. The existing materials will be repurposed into a more attractive multimedia package with clear narration.	Engaging and interactive courseware for independent learning. Aligns with blended approach of e-learning and face-to-face lectures. A variety of different instructional media was incorporated and exploited for a more motivating and stimulating e-learning experience.
• Following completion of Electromagnetism topic, students will work in groups and propose applications in a class presentation to peer-learners	Reflective and collaborative learning as well as active knowledge acquisition. Group work helps students to understand different perspectives and think more critically and reflectively.
• Outstanding cases from students will be collated and incorporated into the courseware	Proliferate learner-generated knowledge

  Tutorial Activities

Learning Activity	**Learner-centred Learning Features**
• For a specific tutorial session, students to attempt Multiple Choice Questions (MCQ) at home (anytime outside classroom tutorial session).	Learning not confined to traditional classroom tutorial - time, pace, place. Student access to range of learning resources other than tutor.

• Following which, students are grouped to play a 'tic tac toe' multimedia game projected by the lecturer, whereby they are challenged to select boxes containing hidden questions. Students will then be engaged to set questions (with solutions) for other groups to solve. • Challenge for developer is to develop multimedia game which facilitates lecturer to enter and refresh questions in an easy and flexible manner through use of XML technologies.	Learning as a fun, participative, highly social, active dynamic process. Encourages active learning which hinges on students' participation in the process of formulating questions and solutions with prompt feedback - 'Democratization of learning space'

Virtual Lab

Learning Activity	**Learner-centred Learning Features**
• Virtual Lab featuring virtual wires, digital multi-meter, breadboard and resistor components that allow students to conduct experiments anytime, anywhere. Virtual lab to augment physical lab sessions.	Interactive, multi-sensory virtual learning experience.
• During lab test week, students to submit a reflection on the learning experiences while using the Virtual Lab.	Reflection on learning experience, application, content, issues and concerns. Opportunity for students to explore their understanding of concepts and hypotheses, promoting reflective practices.
• Students to also submit an experiment (circuit) designed through the Virtual Lab.	Flexibility to design circuit schematics within topic parameters. Authentic tasks and a degree of choice enable students to take ownership of learning and be more active learners.

4.4 Intended Use of Courseware and Impact on Learner-Centred Learning

This section requires the module leader to articulate how the courseware will be deployed to drive his/her teaching practice (i.e. focus on how students are learning, what they experience, and how they engage in the learning context) based on the underpinning Learner-centred Learning concept. The plan for use of courseware should include:

- Topics to be covered
- Teaching delivery methods
- Learning activities
- Assessment activities

4.5 Module Scoping

The module scoping process outlines how the e-learning courseware will impact on the teaching approach of individual topics. With the emphasis on learner-centredness providing the orienting focus for learning design, highly positive learning outcomes is achieved through the *effective integration* of multimedia courseware, constructivist learning and elements of didactic teaching practice. An extract of the module scoping for the Electrical Technology module is presented below:

Topics/ Timetabled Hrs (weekly)	**Nature of product**	**Description of product needed**	**Explanation on how the product feature will enhance/ value add to learning**	**Indication of Learner-centred Learning (LcL) Feature**
Electromagnetism (3 hrs) AC theory (9 hrs)	X Courseware ☐ Training video ☐ Simulation ☐ Game ☐ Activity ☐ Others	An attractive eLearning courseware for 2 topics of Electrical Technology	The development of the courseware will help the students to understand the concept of electromagnetism. By assigning them to form groups and find application after studying courseware, they will reflect on it before making a choice. The sharing session in class will further challenge them as they have to face questionings.	X Collaborating X Reflecting X Exploring/ Researching X Doing/ Producing
Tutorial with gaming like features	☐ Courseware ☐ Training video ☐ Simulation X Game X Activity ☐ Others	Tutorial will allow students to set questions for others to solve.	The process of setting the questions will deepen students' understanding.	X Collaborating X Reflecting ☐ Exploring/ Researching X Doing/ Producing
Virtual Lab	☐ Courseware ☐ Training video X Simulation ☐ Game ☐ Activity ☐ Others	Simulation of real labs by using software to connect and test the circuits.	Students are not limited by physical lab to connect up circuits and take measurements. They can connect all sorts of circuit even those from their tutorials.	☐ Collaborating X Reflecting X Exploring/ Researching X Doing/ Producing

5. Module Leader's Reflections

5.1 Courseware

The topic selected for the courseware is topic 4 on Electromagnetism and Electromagnetic Induction. The reason for selection of this topic is that magnetic field is invisible but it plays an integral part in almost every electrical device used in industry or at home. There exists a magnetic field in the region surrounding a magnet. When a conductor is moved through a magnetic field, a voltage will be induced across the inductor. An attractive multimedia package will be able to show the induced voltage deflecting the pointer of an analogue voltmeter.

The courseware is incorporated with many examples and solutions. Students will be informed to go to the web-site and download the software one week before the time scheduled for this topic. They will access the courseware and solve some questions that test their understanding. During the lecture, they will discuss and clear any

doubts with the help of the lecturer. Students will then form groups of 2 to 4 to find a device that makes use of the application of the electromagnetism or inductor. They have to collaborate to do a class presentation during tutorial using power-point slides. In the presentation, they are required to:

1. name the device of their choice
2. list the main components in the device and
3. describe how it works

The courseware allows the students learn at their pace. The questions that they have to answer and submit will require them to understand the concepts. By searching for the application of electromagnetism through internet or books, students will see the theory applied in so many areas that affect their lives. Examples of the devices that employ magnetic effects are plentiful and some of these are generators, motors, transformers, circuit breakers, relays, computers, speakers. During the class presentations, they are sharing with the class the knowledge they have acquired as well as learning from their peers' findings.

The experience with students during the presentation was that the good students performed very well. However the weaker students (those that did not score well in common test) were able to share what they have learnt with confidence.

5.2 Tutorial

Most students enjoyed the 'tic tac toe' games. It is another way of learning, different from traditional tutorial where they solve questions from the notes. Through this approach, they are engaged to solve questions projected on the screen and learn while taking part in a competition. The set back is that in some classes, there are outspoken students who keep on shouting out the answers before the student assigned to answer has a chance to figure it out.

Suggestion from a lecturer for future consideration: *"**We can leverage on multi-player platform like the "King of the Hill" game where multiple players contest to reach the top of the hill first. They moved simultaneously towards the target by solving MCQ and their movements could be seen real time adding to the excitement of the game."***

After the first hour of the tic-tac toe game, students formed groups of 3 to 4 persons. They discussed and set a question for the other group to solve. The students tried to set challenging questions and provide solutions to give to the lecturer. Most of them put in a lot of effort and time to set one question so much as that there is insufficient class time for the other group to solve it.

5.3 Lab

Students were told to download the virtual lab software during the first lab session. They learn how to use the breadboard by doing series and parallel connections through the software at home before the next lab which will take place two weeks later. A lab sheet that required them to do reflection on the learning experience of virtual lab is to be completed and submitted. The software has five resistors, a multi-meter (for voltage and resistance measurement), a DC supply and a breadboard. When they come to the lab two weeks later fully prepared, they had a much easier time carrying out the experiments. They are ready to connect more complicated circuits and do measurement using real instruments.

6. Courseware Review

Following implementation of the courseware with revised learning design, a survey was administered to determine its impact on students' learning experience.

100 students were surveyed to rate the following statements on a scale of 1 to 5, with 1 being strongly disagree and 5 being strongly agree.

My Learning Experience

- The activities for this topic were interesting
- The online game helped me to develop a good understanding of the topic
- The e-learning courseware helped me to develop a good understanding of the topic
- I would like more topics/lessons to be taught in this way

Design Features of Courseware

- The animated illustrations, graphic images, text, learning games, audio narration and video demonstrate the concepts effectively
- The navigation (moving from one page/topic to another), functional features, interface within the courseware are friendly and intuitive
- The courseware is easy to access

The results of the survey were largely positive, with over 60% of respondents agreeing that the activities were interesting and helped them to deepen understanding of the electromagnetism topic. In terms of courseware design features, over 70% of respondents agreed that the well integrated use of multimedia elements and overall usability design help contribute to their enhanced understanding of key concepts.

The full results are presented as follows:

	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
My Learning experience				**(%)**	
The activities for this topic were interesting.	**4**	**10**	**12**	**66**	**8**
The online game helped me to develop a good understanding of the topic.	**2**	**9**	**23**	**60**	**6**
The e-learning courseware helped me in to develop a good understanding of the topic.	**3**	**6**	**28**	**59**	**4**
I would like more topics/lessons to be taught in this way.	**8**	**15**	**22**	**40**	**15**
The design features of the e-learning courseware					

The animated illustrations, graphic images, text, learning games, audio narration and video demonstrate the concepts effectively.	**4**	**6**	**19**	**61**	**10**
The navigation (moving from one page/topic to another), functional features, interface within the courseware are friendly and intuitive.	**4**	**4**	**19**	**60**	**12**
The courseware is easy to access.	**3**	**7**	**13**	**58**	**17**

7. CONCLUSION

This paper advocates that an effective e-learning courseware infused with learner-centred design principles and interactive multimedia will engender positive educational outcomes. The e-learning approach attempts to compel learners to construct knowledge with the lecturer as a facilitator of learning rather than a provider of knowledge. Learners will be challenged to organise and structure responses to problems, so as to develop a greater depth of understanding. One of the key strengths of the approach is that creative employment of Learner-centred Learning features throughout learning design and delivery will foster deeper understanding.

Ngee Ann Polytechnic's initiative to enhance the e-learning approach by infusing Learner-centred Learning principles into courseware has the potential to lead to an educational experience that is infinitely more interesting, engaging and effective.

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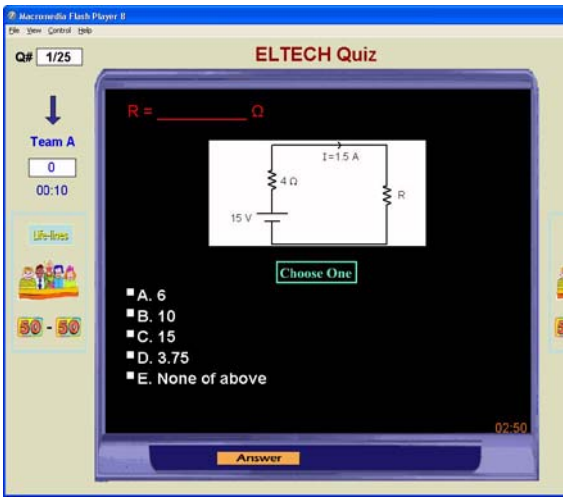
Annex

Screen Shots of 'Tic Tac Toe' Multimedia Game



Screen Shots of the Virtual Lab