DEVELOPMENT OF MEANINGFUL LESSON USING LXD METHODOLOGY FOR AN ENGINEERING MODULE

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ABSTRACT

According to literature, learning is most meaningful when it is deliberately applied in real-life contexts by incorporating real-life contexts that facilitate active, constructive, intentional, and collaborative engagement into learning. This will help learners to achieve longer retention of what they have learned compared to memorising and rote learning. In Nanyang Polytechnic, Singapore, a Learning Experience Design (LXD) Methodology was developed to guide and support educators in the design of good learning experiences that are meaningful to learners and to achieve our goal of engaging and effective teaching and learning. This paper explains how we developed the meaningful lessons for an engineering module, focusing on application, problem-solving and collaboration. To examine whether the learners perceived the learning to be more meaningful after attending the lessons that are redesigned using the LXD methodology, a comparison study was conducted involving about 90 learners in the Diploma of Robotics & Mechatronics. The results indicated that learners in the experimental group perceived more meaningful learning and scored higher in the post-course test than the control group. In addition, the reflection on our experiences in going through the four recommended processes in the LXD Methodology, namely learner discovery, supporting learners in attaining learning outcomes, designing the learning experience, and evaluating for improvement will also be discussed. These reflections can be used as a case study to share with other educators who would like to design meaningful lesson to achieve a more engaging experience for learners. The last part of the paper highlights the challenges faced and provides improvement to further fine-tune and streamline the on-going implementation effort.

KEYWORDS

Meaningful learning, Learning Experience Design, Statistical Analysis, Standard 8 Active Learning, Standard 10 Enhancement of Faculty Teaching Competence

INTRODUCTION

Assimilation theory of learning, used to describe how human is engaged in meaningful learning, is an educational concept introduced by Ausubel (Ausubel, 1963) and later adopted by numerous researchers and psychology educators (Novak, 2007). Meaningful learning refers to binding new knowledge with preliminary information, cognitive mapping structure according to new learnings, and transferring them to daily life (Ausubel, 1963). Therefore, meaningful learning will help learners achieve longer retention of what they have learned compared to memorising and rote learning (Vallori, 2014). In other words, meaningful learning is to incorporate real-life contexts that facilitate active, constructive, intentional, and collaborative engagement into learning. Learning is most meaningful when it is deliberately applied in real-life contexts. Learners can then appreciate what they learn and apply it to new problems. In addition, collaboration is also an essential component of meaningful learning as humans learn better when we are in communities (Johannes, 2006) (Jonassen D. , 2005).

Meaningful learning also provides a model to help educators understand, implement, and evaluate concept-based teaching and suggests that meaningful learning occurs when new experiences are related to what a learner already knows (Teresa J. Getha-Eby, 2014) (Ang & Ngu, 2014). In a further development in 2003, Jonassen and his colleagues applied a constructivist perspective to using technology in schools to create technology-based activities that supported meaningful learning. They defined meaningful learning as occurring when learners were actively engaged in making meaning and identified five attributes of meaningful learning – "Active, Constructive, Intentional, Authentic and Cooperative" with the most meaningful learning activities supporting combinations of these attributes (Jonassen, Howland, Moore, & Marra, 2003). In 2012, Howland et al. demonstrated numerous examples of how different learners could use different technologies for meaningful learning. They also discussed the Assessing Meaningful Teaching and Learning rubrics which give educators a tool for reflecting on their practice (Howland, Jonassen , & Marra, 2011).

THEORECTICAL BACKGROUND

Meaningful learning is an important pillar in the Learning Experience Design (LXD) Framework (Figure 1) that was developed in Nanyang Polytechnic (NYP), Singapore in 2022. LXD (Floor, 2023) is the science and the art of creating experiences that helps learners fulfill the learning outcomes they desire, in a user-centered and goal-directed way. In NYP, the LXD Methodology embodies LXD principles, best practices, and research findings, and it is about creating Meaningful, Motivational and Memorable learning experiences that address the needs of learners, achieve the learning outcomes, and build propensity for life-long learning. It guides lecturers through the four processes in LXD, namely learner discovery, supporting learners in attaining learning outcomes, designing the learning experience, and evaluating for improvement, in a cyclical and iterative manner, with the goal of creating and conducting engaging teaching and learning. Teoh's study (Teoh) demonstrated that using NYP LXD Methodology to design lessons for an engineering module based on learner's need and motivation, which is one of the domains in user experience and instructional design, increases learners' level of understanding.

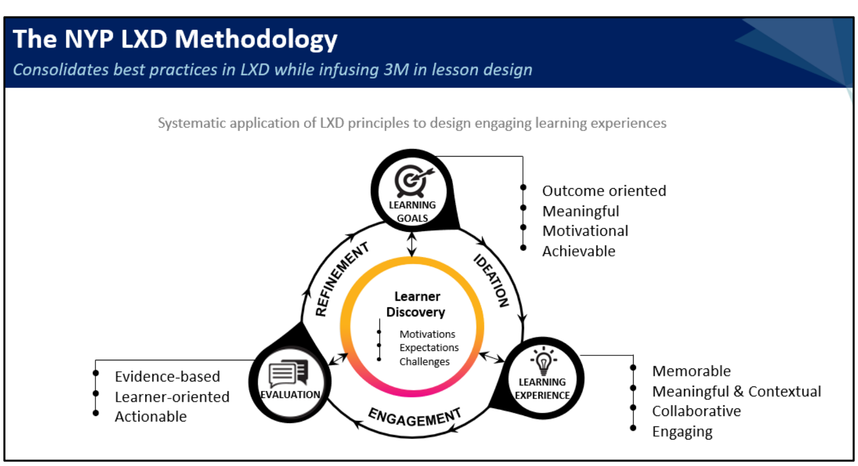

Figure 1: NYP LXD Methodology/Framework

This study sought to describe how we developed the meaningful lessons for the topic on Encoder of an engineering module, guided by NYP LXD Methodology and aimed to increase the confidence of learners in working collaboratively and responsibly with others, leading to a more meaningful learning on Encoder. This paper is divided into three sections. Part one provides an overview of the background on why the topic on Encoder was chosen and the two questions this paper will address. Part two deals with the research methods and part three discusses the results and the last part we will make a conclusion to this study.

Encoder (Realpars, 2023) (Fun, 2023) is one of the challenging topics that learners need to complete in a Year 2 engineering module from the Diploma in Robotics & Mechatronics (DRM). Before applying LXD Methodology, we taught encoder using National Instrument Sensor Training board (Figure 2) and focused on theoretical aspect where learners lack of appreciation on where and how the encoder can be applied. While some attempts, such as video curation, were made to link Encoder to real-life context in past few years, many learners still find the topic to be abstract and have difficulty linking the theory to real life application. And the test score for the topic on Encoder was always low compared with other topics in the same module. Hence, we embarked on an action research project to redesign our lesson and activities guided by NYP LXD Methodology focusing on the meaningful aspect of the NYP LXD Methodology.

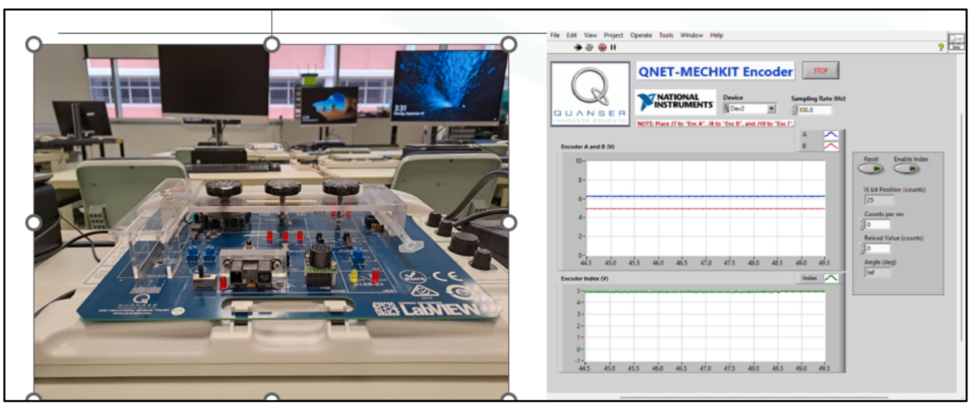

Figure 2: Encoder training before LXD implementation

The meaningfulness in NYP context, focus on 3 dimensions: application, problem solving and collaboration. For application, it is defined as the ability to use the learned materials in new real-life situations. This may include the application of rules, methods, concepts, principles, law, and theories. For problem solving, the definition adopted is the synthesis of learning and application in new and different situations to propose solutions and consider alternatives to a problem. For collaboration, the definition adopted is that learning occurs when two of more learners learn together through dialogue and social interaction, considering each other's perspectives and experiences to solve problems and develop a shared understanding of meanings. The first question that we would like to address is therefore the extent of learners perceiving the learning of Encoder to be more meaningful after attending the lessons that are redesigned using the LXD Methodology.

The NYP LXD Methodology is new and there was limited information on how NYP LXD Methodology leads to the design of learning experiences which are meaningful. Hence the second question we would like to address is the usefulness of NYP LXD Methodology in helping lecturers to design meaningful learning experiences for learners.

METHODS

Participants

The study involved about 90 Year 2 engineering learners from DRM. The first group (n = 46, control group) used the existing curriculum in Oct 2021 semester (2021 S2), while the second group (n = 45, treatment group) used the enhanced curriculum which was redesigned for meaningful learning in April 2022 semester (2022 S1). For both the control and treatment groups, the instructors and learners met face-to-face twice per week, once for the 2-hour practical session and again for a 1-hour problem solving tutorial. The participants were not randomly assigned to either the control or treatment group, rather we assigned 2021S2 batch as the control group and 2022S1 batch as the treatment group. Both groups were conducted by the same instructors and the module is a 15-week, compulsory module for all learners from DRM. Ethical approvals for data collection and leaner consent were obtained before its implementation.

Research Design

The NYP LXD Methodology provides a systematic application of learning experience design principles to guide staff in the process of creating and conducting engaging lessons. The four LXD processes were implemented as follows:

(1) Learner Discovery – the aim of this first process was to allow staff to empathize with our learners and it involved three steps:

Step 1: We conducted a Focus Group Discussion (FGD) with learners to have an in-depth understanding of their learning experiences on Encoder in terms of meaningful learning domain. 12 learners from control group who went through the existing curriculum on Encoder in 2021S2 were invited to the FGD. The FGD was facilitated by two instructors using the following guiding questions as shown in Table 1.

Table 1: Guiding Question for FGD (Control Group)

Q1	Is the encoder topic very difficult to learn? Why or why not?
Q2	Which part of the delivery of Encoder helps you to learn better/interests you the most?
Q3	Based on your years of study at NYP, recall a difficult topic that you have learnt well
Q4	What was that topic and what was the most important thing the lecturer did in that module to help you learn well?
Q5	Do the class activities (Lecture/Tutorial/Practical) allow you to apply problem-solving skill?
Q6	Do the class activities (Lecture/Tutorial/Practical) make you think about a problem and try to solve it?

Step 2: Once we gathered the input from the 12 learners through the FGD, we consolidated their responses into Persona

Step 3: Once we had a good understanding of the Persona, we used this Persona to design the learning experiences

(2) Learning Goals – the aim of this second process was to support learners in attaining learning outcomes by listing down the learning outcomes on Encoder that the learners need to achieve

(3) From Ideation, Learning Experiences to Engagement – with the learning goals and the persona at hand, we redesigned the learning content and activities on Encoder to be in line with the learners' abilities and needs in this third process. We followed the criteria for lesson design of the three dimensions on meaningful learning closely, namely application, problem solving and collaboration. In terms of application of Encoder, we contextualized the lesson to real-life situation and facilitated the application of learner knowledge and skills gained from the classroom learning to real-life settings. In terms of problem solving, we infused critical thinking in lesson design by designing activities to develop learners' problem-solving, questioning, and critical thinking skills. In terms of collaboration, we incorporated activities that requires learners to work collaboratively and share responsibility. Figure 3 shows a real-life measuring wheel laboratory kit using encoder.

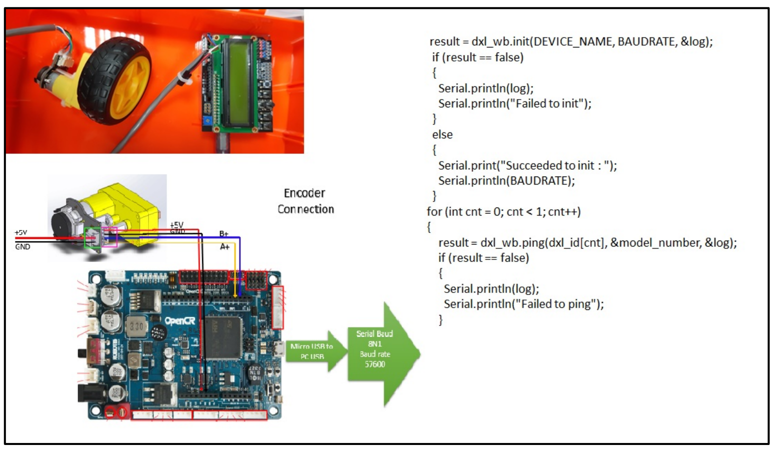

Figure 3: Measuring wheel laboratory kit development

(4) Evaluation to Refinement – the aim of this fourth process was to collect data about the redesigned lessons to allow staff to know whether the redesigned lessons on Encoder provide meaningful learning experiences for the learners. One key consideration was to choose the survey instruments to be administered to learners to measure their meaningful learning experiences. The other consideration was to decide on the platform to be used to administer the survey to learners.

To address the second question on the usefulness of NYP LXD Methodology in helping lecturers to design meaningful learning experiences for learners, we documented our experiences in a reflection journal as we walked through the four processes. For example, in the first process of learner discovery, we documented our experiences on choosing the participants (i.e., volunteering, nominated, sampled), getting participations from learners in the FGD, and crafting the guiding questions that are aligned to the LXD methodology. Another example would be in the third process, we documented our experiences which include key design decisions and justifications in the redesigning of the lessons on Encoder and key consideration in choosing the tools to be used to develop the learning materials and activities.

DATA ANALYSIS AND RESULTS

Data Collection

To answer the question on, to what extent do learners perceive the learning of Encoder to be more meaningful, we conducted a quantitative survey in 5-point Likert Scale (Strongly disagree -1, Disagree – 2, Neutral – 3, Agree – 4, Strongly Agree -5) to 46 learners in control group in 2021S2 and 45 learners in treatment group in 2022S1 where the profile of these two groups of learners was similar. The survey instruments that were administered to learners can be found in Table 2.

Table 2: Quantitative Survey Questions (NYP LXD)

Q1	Meaningful	Application	The lessons provide opportunities for me to apply acquired knowledge & skills.
Q2		Problem-Solving	The lessons provide opportunities for me to develop problem-solving skills.
Q3		Collaboration	The lessons allow me to collaborate with my classmates more often.
Q4	Motivational	Attention	The lessons captured my interest and inspired me to explore more about the topics taught
Q5		Autonomy	The lessons incorporate materials and activities that allow me to choose the pacing and intensity of learning
Q6		Confidence	The lessons allow me to achieve small success while I progress to achieve the learning goals
Q7	Memorable	Appreciation	I can appreciate the learning content and objectives because they were clearly introduced
Q8		Connection	I am given the opportunity to express my feelings freely while exploring ideas during lessons

While our study focuses on the meaningful domain of LXD, we decided to collect data on the motivational and memorable domains as well to examine how the change of redesigning lessons in the meaningful domain impacts to the motivational and memorable domains.

Data Analysis

Figure 4 tabulates the mean values of the quantitative survey data from both groups. It shows an overall increase in rating by treatment group for all the 8 questions, indicating that learners from treatment group perceived the redesigned material to be more meaningful, motivational and memorable.

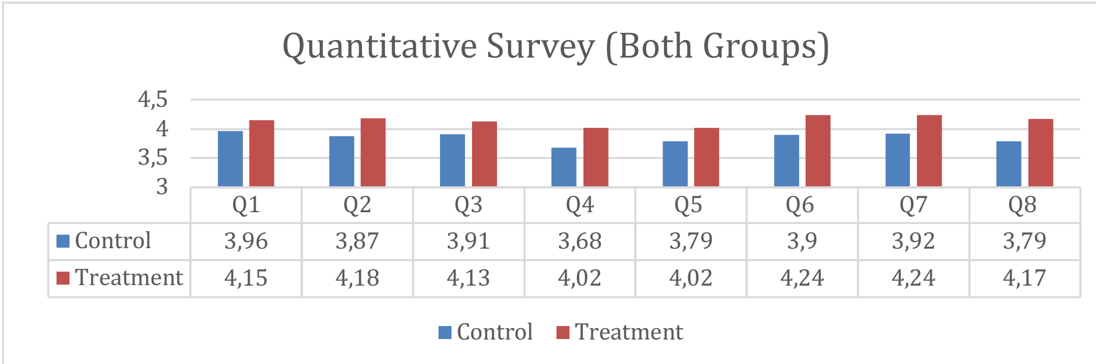

Figure 4: Quantitative survey for both groups (5-point Likert Scale)

To exam how significant difference in perceiving meaningful learning among control and treatment group, we carried out a statistical analysis to the quantitative survey data. Paired samples t-test is normally used to test if the means of two pairs measurements, such as pretest/posttest scores, are significantly different [15]. Hence, we conducted paired sample *t*-test, set test value alpha as 0.05 and hypothesized mean difference as 0 and obtained the value of p in Table 3.

Table 3: Paired Sampled t-Test Result

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
P(T<t) two-tail	0.020	0.0065	0.16	0.02	0.08	0.02	0.021	0.016

We observed that p values for all the questions are less than the test value alpha of 0.05 except for Question 3 on Collaboration and Question 5 on Autonomy.

The findings implied that learners did find the redesigned Encoder lessons to be meaningful in the application and problem-solving dimensions. Perhaps in our design of collaborative learning activities, instead of assuming that learners know to work collaboratively, we should first introduce the meaning of collaborative learning to learners, in terms of how they should explain concepts, justify and defend their perspectives and approach to others in a cordial and respectful manner.

It is interesting to note that learners would prefer lecturers to incorporate materials and activities that allow them to choose the pacing and intensity of learning. This is so that they are given some degree of choices in what they want to learn and how they want to learn. Perhaps we could investigate this aspect of personalized learning as we continue to improve the lesson materials and activities on Encoder.

Documentation and Reflection

To answer the question on how LXD Methodology helps lecturers to design meaningful learning experiences, we document our critical design decisions and justifications of the lessons on the encoder and the key consideration in choosing the tools to develop the learning materials and activities. We also documented our thoughts and opinions - these include what we like, what kind of improvement we would like to see, any questions or related question that came up from the idea or setup, and any other ideas that we can explore that will enhance the lesson.

We found that the LXD Methodology is valuable to help lecturers design meaningful learning experiences for our learners as it provides a set of lesson design criteria that guides lecturers in creating and conducting engaging learning experiences. It can help us to focus on the three dimensions (meaningful, motivational, and memorable) one at a time. Lecturers can begin the LXD processes from any dimension, and the impact of engaging learning experiences will be enhanced in all three dimensions.

In addition, it is challenging to engage all the learners participating in our survey (92 participants out of 130), and a lot of time is needed in designing, documenting & delivering meaningful redesigned lessons and activities than the regular curriculum.

Finally, we reflected by triangulating two data sources, the recorded journals and the learner's feedback from the Focus Group Discussion. We felt that the measuring wheel laboratory kit and the redesigned lesson improved and addressed the initial struggle of the student not finding meaningful in the study.

CONCLUSION

We found the LXD Methodology to be useful in designing meaningful learning experiences for our learners as it provides a set of lesson design criteria that guides lecturers in the creation and conduct of engaging learning experiences. There is no need to focus the lesson design on the three dimensions (meaningful, motivational, and memorable) in one go. Lecturers can begin the LXD process from any dimensions and the impact of engaging learning experiences will be enhanced in all three dimensions.

We managed to reflect and journal our experiences in going through each of the four recommended LXD processes. While it is time consuming to document each step of our journey in re-designing the lessons and activities on Encoder, we realized that this process of documentation and reflections provides us an opportunity to perform self-observation along with self-evaluation. It is important because we can identify the kind of LXD processes that we took, analyzed the thoughts we had in how we deliver the lessons and evaluate the outcome for future improvements including decision making, justification on specific contents, delivery methods, learner survey and challenge faced. It can be shared with lecturers who are interested in developing meaningful lessons to learners. These reflections also provide opportunities for us to recommend further refinements to the LXD processes. The next step is to collect feedback from other lecturers on the usefulness of these case studies.

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BIOGRAPHICAL INFORMATION

Dr Zhao Meijun holds a PhD degree in Robotics & Mechatronics. She has more than 12 years' experience on education and robotic development in NYP. Her research and development interests: AI in education, Teaching & Learning (T&L) pedagogy and competency-based T&L.

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Flex Tio is a Senior Specialist in T&L and Senior Lecturer with NYP, teaching software development and engineering practices. He was a research and development engineer with the Government of Singapore specializing in Visual Analysis and Text Analysis. He is the lead of the LXD workgroup in NYP, driving initiatives that target to improve learner engagement. He also has a keen interest in ICT-Enable T&L and Active learning, often exploring education pedagogy seeking to engage learners in understanding how hard skills and heart skills work together in the real world.

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