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Enhancement of Transformative Learning in Large Classes of Leaners in Engineering Education

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Abstract. Engineering education in the universities and colleges involves the combination of cognitive learning theory and experiential learning theory to ensure transformative learning. These theories form part of the conceptual frameworks that describe how information is absorbed, processed, and retained during engineering education and training. While the application of cognitive learning theory in engineering education focuses on understanding the learners with regards to the complexities of human memory, experiential learning theory aims at developing in the learners the societal technical observation and community commitment skills necessary to shape and transform them into competent young engineers. In addition, transformative learning theory seeks to explain and enhance how the learners revise and reinterpret information acquired during engineering education. Therefore, the combination of the cognitive learning theory and the experiential learning makes the application of transformative learning effective in engineering education. In addition, transformative learning provides an individual the opportunity to acquire experience, question some assumptions during learning, and reflect on them at the later stage. However, the degree of the enhanced transformative learning in engineering education is forestalled by the size of class we have in our universities today. Therefore, it is essential to know the effects of large class of learners on transformative learning in engineering education and how these effects could be minimized to promote transformative learning. In this article, effects of large classes on effective transformative learning in engineering education are enumerated, and suggested solutions to alleviating these effects are discussed.

1. Introduction

Engineering education in the universities and colleges involves the combination of cognitive learning theory and experiential learning theory of learning to ensure transformative learning. These theories form part of the conceptual frameworks that describe how information is absorbed, processed, and retained during engineering education and training. While the application of cognitive learning theory in engineering education focuses on understanding the learners with regards to the complexities of human memory, experiential learning theory aims at developing in the learners the societal technical observation and community commitment skills necessary to shape and transform them into competent young engineers. Furthermore, transformative learning theory seeks to explain and enhance how the learners revise and reinterpret information acquired during engineering education and training [1]. Figure 1 presents an illustration of the dependence of transformative learning on cognitive and experiential theories of learning in engineering education because knowledge is continuously amassed via both personal and environmental experiences [2].
Figure 1. Cognitive learning theory (CLT) and Experiential Learning Theory (ELT), the two strong pillars of the transformative learning in engineering education and training

It is very interesting to know how the combination of the cognitive learning theory and the experiential learning makes the application of transformative learning effective in engineering education. In addition, transformative learning provides an individual the opportunity to acquire experience, question some assumptions during the learning and reflect on them at the later stage. Therefore, learning in engineering education is expected to transform the mind and the transformation is expected to be noticed by the learners and the society because transformative learning should shape people and re-orientate their minds. Therefore, the curriculum of engineering education and training in the higher institutions is cognitively designed with experiential learning as its core, and tailored towards developing critical and creative thinking skills that are essential in engineering practice.

Furthermore, variety of assessments administered in engineering education are purposed to provide the engineers-in-the-making the ability to evaluate evidence, appraise situations and circumstances to draw logical conclusions with respect to the analysis. Consequently, these assessments, that encourage transition from assessment of learning to assessment for learning, should transform the learners. However, the degree of the enhanced transformative learning in engineering education is forestalled by the size of the classes we have in our universities today. Therefore, it is high time we investigated the impact of large classes on transformative learning in engineering education and training in our higher institutions. Because knowing and understanding the effects of the size of classes on the degree of transformative learning in engineering education could pave the way to proffer lasting solutions to the problems. Several questions came to my mind in the process of investigating this problem. The key questions that should be addressed are: What are the effects of large class on transformative learning in engineering education? How can these effects be eradicated or minimized to promote transformative learning? How can the ways of minimizing these effects be integrated into engineering education curriculum to promote the acquisition of required skills in engineering profession?
2. Effects of large classes on transformative learning in engineering education

2.1. Untimely feedback
In engineering education, assessment and feedback on assessment are targeted at competence development. Therefore, it is imperative to understand the effect of feedback on student’s conscious competence and unconscious competence towards enhancing transformative learning. Moving the unconscious competence to conscious competence in engineering education could enhance the acquisition of critical thinking skills expected of an engineer. However, this could be achieved effectively during one-on-one feedback session which could be time-consuming in a large class.

In agreement with Gibbs and Simpson [3], timely provision of feedback to learners could provide enough time for them to receive further assistance, thereby enhancing the conception of knowledge and acquisition of skills. This is very true in engineering education and training where experiential learning is crucial to developing critical and creative thinking skills required as a professional engineer. But how will a teacher who must be involved in active research and other administrative issues provide timely feedback to students? In fact, this problem is aggravated if the class is a large class. How do we expect the teacher to strike the balance between teaching, research and administration knowing that his/her career development and promotion depends heavily on the research output? How do we effectively transform the minds of the learners via an enabling environment that promotes and supports transformative learning in our universities without having to reduce the yearly in-takes into the universities?

2.2. Unsustainable assessment
Improving standard of education depends strongly on improving student learning efficiency [3]. Furthermore; assessment should be a medium to encourage experiential learning that could lead to transformative learning. For example, training of young embryonic engineers through engineering education requires a form of assessment that will enable them to have reflec tion-in-action and reflection-on-action during the training [4]. To acquire transformative learning that will with impact positively on the society depends strongly on the assessment methods employed during the teaching and learning. A learner will benefit a lot from assessment that is formative in nature because the knowledge and skills acquired through this assessment method are retained for a long time. However, the most reliable, rigorous and cheat-proof assessments system, that considers assessment as a yardstick for standard measurement, results into lifeless learning and unsustainable assessment [3]. Therefore, assessment that will support sustainable and transformative learning should not be too rigorous and not accompanied by lifeless learning since assessment system exerts great influence on students [5].

Thus, the type of assessment required in engineering education and training is the one that provides the engineers-in-the-making the ability to evaluate evidence, appraise situations and circumstances to draw logical conclusions with respect to the analysis. But the key question is: could the current assessment methods in engineering education in our universities promote transformative learning in large classes? As a means of providing conditions that will support transformative learning in higher education, Boud and Soler suggested coursework assignment assessment system rather than the summative assessment [4]. This is well applauded because the performance of students could be enhanced via coursework assignments. In addition, the coursework assessment could promote transformative learning if conducted in formative way. Furthermore, the coursework assignment could promote sustainable learning if detailed personalized feedback is frequently provided to the learners. However, the effectiveness of the coursework assignment, as a formative assessment method, might be hampered by the size of the classes. Administration of the coursework assignment in a large class is time consuming and rigorous. Therefore, the size of classes in our universities in the recent times has contributed to the dramatic decline in the use of formative assessment method in universities. Furthermore, large class constrains the available resource resulting in the decline of quantity and quality of feedback.
My recent experiences in the use of formative assessment in large classes to enhance transformative and experiential learning in chemical engineering education and training has made me to query the effectiveness of employing formative assessment in large classes. After the experiences, my mind has been clouded with one-million questions, a few of which are: are there ways by which transformative learning via formative assessment could be achieved in large classes in engineering education? What are the constraints mitigating effective transformative learning via formative assessment in a large class? How can the different forms of assessment and feedback be integrated into engineering education curriculum to promote acquisition of required skills in engineering profession via experiential learning? Furthermore, if providing quality and timely feedback to students could optimize the projected performance of a formative assessment in learning, then how can a quality and timely feedback be provided in a large class?

3. Enhancing transformative learning in a large class in engineering education

3.1. Providing timely feedback in a large class
In the field of engineering, fundamental knowledge is transferred to the learners by the teachers to help the learners cultivate or build critical thinking skills through the understanding and application of various engineering concepts. Gibbs and Simpson suggested that timely provision of feedback to learners could provide enough time for them to receive further assistance, thereby enhancing the conception of knowledge and acquisition of skills [3]. How could quality and timely feedback be provided to students in a large class?

Gibbs and Simpson suggested that audiotaping during feedback could assist in providing timely and quality feedback to students because students could re-play the recorded feedback repeatedly until they fully understand the feedback [3]. This could be a good option in providing timely and quality feedback in a large class in engineering education. However, the use of audiotaping application could be hampered by insufficient technical devices and in some cases non-availability of required technologies to embark on it. In addition, the use of videotaping in giving feedback might require an extra assistance from another person who will videotape the discussion. In addition, this method could be effective when providing feedback to the whole class but not for one-on-one feedback. To alleviate this effect, Race suggests the use of shorter assignments and the number of assignments should be considerably reduced [6].

3.2. Developing a sustainable assessment in a large class
As a way of developing sustainable assessment in large classes in engineering education, Beck et al. suggest that course tutorials and lectures at the universities should be targeted at developing independence, intellectual maturity and creativity [7]. To ensure this is achieved at the universities, periodic monitoring of performance and progress of students using rubrics and reflective sessions is essential. Self-assessment by students proposed by McDonald [8] could be an excellent technique by which sustainable assessment could be promoted in a large class in higher education, especially in engineering education. Self-assessment could enable the teachers and the learners to identify the needs and ways to meet them. Sustainable assessment in large classes in engineering education also could be realizable using “Flipped classrooms”. Furthermore, any assessment that will support sustainable and transformative learning in large classes should not be too rigorous and not be accompanied by lifeless learning [5].

3.3. The use of a flipped classroom
Recently the use of flipped classroom was proposed and canvassed for as an excellent option to promote transformative learning in large classes in higher institutions. The flipped classroom is defined as a pedagogical approach whereby the traditional teaching approach and homework elements of a course are reversed. In this approach, students are made to view short videos or listen to audiotapes of lectures at home before the class session, and the normal class time is devoted to class exercises, discussions and case studies [9,10]. Compared to the traditional teacher-centered teaching and learning approach where the teacher is the primary source of information, the flipped classroom learning approach uses the learner-centered mechanism. Detailed comparison between the traditional teaching and learning model and the flipped classroom teaching and learning model is presented in
Table 1. In the learner-centered approach, the normal class time is dedicated to exploring topics in greater depth through exercises and case studies, thereby creating rich learning opportunities for the learners. In addition, this approach encourages active participation of the students and provides an avenue for the learners for personal evaluation.

Table 1. Comparison between traditional classroom and flipped classroom teaching and learning models [9,10]

| Traditional classroom teaching and learning model | Flipped classroom teaching and learning model |
|--------------------------------------------------|---------------------------------------------|
| Teacher prepares material to be delivered in class | Teacher records and shares lectures outside the class |
| Students listen to lectures and other guided instruction in class and take notes | Students watch/listen to lectures before coming to class |
| Homework is assigned to demonstrate understanding | Class time is devoted to applied learning activities and higher-order thinking tasks |
| Little time for students to receive supports from teacher and peers | Students receive support from teacher and peers as needed |
| Students may miss classes due to legitimate reasons | Missing classes due to legitimate reasons is no longer a problem |
| It does not help busy students to plan their learning properly | It helps busy students to plan their learning very well |
| It does not enhance student-teacher interaction | It enhances student-teacher interaction |
| No flexibility for students to choose when and where they learn | It creates flexibility for students to choose when and where they learn |
| Educators are not flexible in their expectations of student timelines for learning and in their assessments of students learning | Educators are flexible in their expectations of student timelines for learning and in their assessments of student learning |

Despite the advantages of a flipped classroom teaching and learning approach over the traditional teaching and learning approach, it cannot replace the teacher. In addition, it does not encourage students to work alone. It is worthy to mention that it is not an online course but just a way to change what is done in class to promote transformative teaching and learning in large classes. As a matter of fact, the effective implementation of the flipped classroom approach could be thwarted by the affordability of required technology by the learners. Despite the aforementioned drawback, the flipped could be an excellent option to enhance teaching and learning in large classes in engineering education and training. In addition, the implementation of the model could pave the way for the development of other approaches that could enhance transformative learning in large classes in our higher institutions.

4. Conclusion
As much as one might be passionate about making teaching and learning a transformative medium through which minds of students are transformed, achieving transformative learning in large classes has been a mirage. As much as one could always purpose to make teaching and learning in large classes a medium through which the learners could acquire experiential learning that will shape their lives, but one is often discouraged by the outcome after using the traditional teaching and learning model. However, the embrace of flipped classroom model integrated with sustainable assessment and timely feedback could be instrumental to achieving the transformative learning in large classes in engineering education and training in the higher institutions.

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