# Reflective learning in a large core course in mechanical engineering

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**Abstract**

This paper *proposes* to introduce reflective learning in a large core course in mechanical engineering. Effectiveness of reflective journals as a pedagogical tool in nurturing metacognitive learning skills in students—with a view to leading them to life-long learning— is proposed to be investigated. Reflective learning within the framework of authentic teaching in a subject-centred teaching and learning environment will be studied. Sample journal questions and assessment criteria are presented for further refinement.

## 1 Introduction

Teaching and learning in a large class brings a unique set of pedagogical and resource challenges. At the University of British Columbia, the author is involved in teaching a large core course on mechanical vibrations (MECH 364) in the Department of Mechanical Engineering. The course is a four credit course comprising lectures, tutorials, and a lab component. Typical class size is 80, if not more. The course is compulsory as the knowledge and skills related to vibrations is deemed essential in the training of mechanical engineers. This requirement brings students to class with varying degrees of motivation and interest in the subject matter. Students from other engineering programs attend this course too, making this a challenging large class.

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Canadian Engineering Accreditation Board (CEAB) has identified life-long learning as one of the desirable student attributes [1]. CEAB defines life-long learning as "an ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge." How does one incorporate this learning goal in the context of a large classroom setting is the question this work seeks to address.

The paper begins with a review of literature in Section. 2. Relevant frameworks and research questions are identified in Section. 3. This is followed by research methodology, assessment rubric, and a brief discussion of implications in Section. 4. Section. 5 concludes this proposal.

# 2 Literature Review

This research proposal is situated within the context of Scholarship of Teaching and Learning (SoTL) literature. Relevant learning principles, strategies, and teaching frameworks are to be considered first.

Ambrose et al. [2] model learning as a process that involves change in knowledge, beliefs, behaviours, or attitudes. They view learning as not something done to students, but rather something students themselves do in response to their experiences. From this perspective Ambrose et al. [2] have enunciated seven research based principles of learning. One of these learning principles that closely resonates with the CEAB attribute mentioned earlier in Section. 1 is "to become self-directed learners, students must learn to monitor and adjust their approaches to learning." This constant monitoring of one's own approach to learning can be seen as a reflective learning process.

Learning is the central theme within the framework of the Scholarship of Teaching and Learning [3, 4, 5, 6]. Underscoring the importance of theory to maintain the rigours of scholarship, Kanuka [6] has identified different classes of learning strategies from earlier works in educational research literature. Cognitive strategies are concerned with the processes to construct knowledge, such as, selection and rehearsal (rote learning or learning to reproduce); elaboration and organizational/scaffolding (deep learning or learning to understand). Metacognitive strategies are concerned with regulating the cognitive and affective strategies. Affective strategies are concerned with emotional status and motivation, anxiety and fear towards learning. Thus, metacognitive learning strategies are central and hence their importance to this investigation. Research studies have shown that emphasis on metacognitive skills in teaching and learning leads to better performance outcomes, see [6, 7] and references therein. Reflection actualizes metacongitive skills.

Parker Palmer [8] proposed a subject-centered framework in which the teachers not only convey their enthusiasm about the subject but also how and why the subject matters. In a subject-centred approach to class-room, teachers seek to establish a connection between the subject matter and students. Kreber [5] proposes to view SoTL as an authentic teaching practice constructed around horizons of significance based on earlier work by Taylor [9]. Kreber et al. [10] elaborate this further by identifying dimensions of authenticity. One horizon of significance that Kreber cites in [5] is that students, while attending our institutions have a learning experience that is worthwhile and promotes their learning and development. Subject matter then is not merely a curriculum prescription but an integral part of a teachers self and the values they place on their subject. It is hypothesized in this study that subject-centered teaching will lead to a deep and lasting engagement between the subject and the student, because it entails nurturing a relationship between the student and the subject beyond the classroom.

In summary, reflection on behalf of the students promotes metacognitive learning strategies resulting in self-directed learners. Nurturing reflection in a subject-centered teaching framework can lead to addressing the requirements of CEAB for life-long learning. It is worth considering the literature relevant to reflection and reflective learning.

Reflection is an essential component of Kolbs experiential learning cycle. Critical reflection leads to transformative adult learning resulting in changes in frames of reference [11]. In reflective learning the students not just take the knowledge as "given", instead they actively construct new knowledge structures/meaning schemes through critical thinking, reasoning and analysis [11, 12]. A cumulative change in meaning schemes results in changes in meaning perspectives leading to transformative learning.

It is clear from the above literature that enhanced metacognitive skills through critical reflection can have a positive impact on students' learning and their relationship with the subject. Is there any evidence for this in engineering education literature? The engineering literature is scant. Statistical evidence for enhanced learning through reflective journal writing has been presented by Burows et al. [13]. Learning journals have been used to encourage students to actively reflect in Engineering Design Courses by Seepersad et al. [14] which lead to students gaining a "deeper understanding of design methods". Reflective journals have also been successfully used by Broadway et al. [15] and by Palmer [16] in an on-line format for a management course. The literature in engineering suggests a broad support to employ reflective journals as an effective pedagogical tool in smaller class rooms and in teams. However the effectiveness of a reflective journals in a large class room in a subject-centered teaching environment remains to be explored.

# 3 Conceptual Framework and Research Questions

Reflective journals as a pedagogical tool to promote life-long learning goal can be considered within the framework of a subject-centred teaching and learning environment.

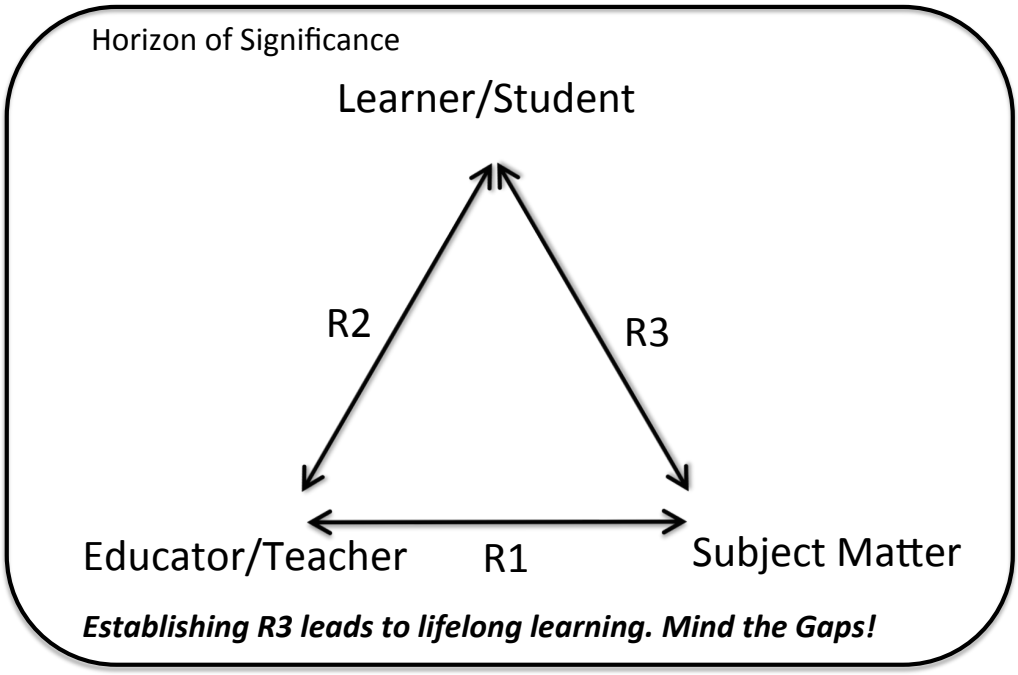


Figure 1: A teaching framework Inspired by Parker Palmer [8], Charles Taylor [9], and Kreber [5, 10].

The schematic above portrays the essential facets of a subject-centred teaching framework. Here, the teacher first establishes a deep relationship with the subject matter through the relationship $R1$ in the schematic. This comes from expertise in the subject matter and practice. The teacher then introduces the subject matter to the students in order to nurture a relationship $R3$ between the subject matter and the students. The role of the teacher thus is merely to serve as a guide to the landscape of learning, dispensed at the end of the journey. An essential component to realizing $R3$ is to establish a constructive relationship with the students through $R2$. This can be achieved, for example, through inspiring interest in the subject matter, instilling confidence in the students in their ability to learn, providing experiential

and reflective learning environments. Once $R3$ is established the teacher is no longer required and the learner transforms into a life-long learner, one of the graduate attributes specified by the Canadian Engineering Accreditation Board (CEAB). The gaps indicate the effort that the teacher/learner has to make on their own.

The classroom research questions to be studied within this framework are:

1. How can we implement reflective journals as a pedagogical tool to assess the critical reflection of students on the subject matter in the context of a large class?

2. Questions pertaining to the logistics of implementing reflective journals: what form should the reflective learning journals take? which suggestive questions to ask the students to guide (rather than enforce) reflection? how often should the formal reflections be sought from the students?

3. How to assess the quality and impact of reflections?

# 4 Methodology

A pilot study is being considered employing student survey tools that contain numeric and descriptive questions. In the beginning of the course, students will be introduced to different learning styles and asked to assess their own learning styles through online survey tools such as Felder-Solomon's ILS, Myers-Brigg's MBTI. Finding one's own learning style is likely to add more value to the reflection process and self diagnosis.

## 4.1 Structure of Reflecting Journal

A compact and structured reflection journal questionnaire is developed based on the existing literature. Suggestive questions will be asked to guide the reflection process, allowing the reflection to be sufficiently open-ended. Weekly or Bi-weekly reflections on the learning activities pertaining to the course (lectures, homeworks, tutorials, lab) will be sought and assessed for feedback. In order to maintain the additional work manageable for the students, some of the questions will use Likert scale while some are descriptive. See Appendix A for reflection journal questions. The journals are designed such that the additional paper work will not exceed 5 pages per student. Implementing the journals online will be considered in the future.

### 4.2 Assessment Rubric

Assessment is a major challenge for the reflection journals as they touch metacognitive and affective domains. A rubric based on Bloom's taxonomy will be considered initially. To receive a baseline credit (grade B) students are expected to recall and describe their experiences. To receive additional credit (B+) students are required to interpret or explain their experience at the next levels of taxonomy (comprehension, application, and analysis). To receive the maximum credit (B++) students must evaluate their experiences at the highest level of the Bloom's taxonomy with reasoned argument and synthesis. The *qualitative* nature of the grading is meant to provide feedback without distracting them from the intended goal of reflection and critical thinking. Detailed quantitative translation of these qualitative grades will be decided towards the end of the class during the first year of this study. The last lecture will be reserved for selected student and teacher reflections.

### 4.3 Implications

To the best of my knowledge reflective journals are not used in my department in any course. If successful, reflecting journal may be used not just in MECH 364 but in other undergraduate and graduate courses.

## 5 Conclusions

Critical reflection by students is essential to actively construct knowledge. The use of learning journals as a pedagogical tool to guide and assess reflective learning in a large class is certainly ambitious, but, a worthy goal given the demonstrated benefits of shifting teaching and learning from cognitive to metacognitive domains. The results from the initial pilot study will be used to refine and fine tune the reflective journal pedagogical tool.

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## A Tentative Journal Questions

# Guiding Questions for a Reflective Journal

## Guidelines

1) Write the following numbers in each column unless the question is indicated as descriptive.

*1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree*

2) For descriptive question write a few sentences on the second page (reverse side of the page with table) based on your own reflection. Use a separate sheet and attach, if required. Keep the descriptive answers/reflections brief, a minimum of two to three sentences suggested. Do not exceed ten sentences. This descriptive part portrays your 'reflection' on the course material and the specific question.

3) Fill-in the concept map sheet as you go along. Feel free to use your imagination to sketch and relate the concepts you are learning from this course or from other courses that you find are useful in this course.

**Lectures and Tutorial**

| | **Week 1** | **Week 2** | **Week 3** | **Week 4** | **Week 5** | **Week 6** | **Week 7** | **Week 8** | **Week 6** | **Week 9** | **Week 10** | **Week 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Describe your learning goals for this week's lectures **(Descriptive**) | | | | | | | | | | | | |
| I am well prepared for this week's lectures with required background knowledge. | | | | | | | | | | | | |
| I can relate this week's lectures to my previous knowledge | | | | | | | | | | | | |
| I understood the concepts and examples presented in this week's lectures | | | | | | | | | | | | |
| What learning objective can you identify in this week's lectures? | | | | | | | | | | | | |
| What changes in your knowledge have occurred after this week's lectures **(Descriptive)** | | | | | | | | | | | | |
| Are there learning difficulties you faced in this lecture? (Yes or no) | | | | | | | | | | | | |
| How do you intend to resolve them? What specific steps do you intend to take **(Descriptive if the answer to the above question is yes)** | | | | | | | | | | | | |
| Describe an important concept you learned this week/important application you can understand better/interesting problems you encountered related to this course. | | | | | | | | | | | | |

**Reflections on Lectures and Tutorials (Descriptive)**

**Homework Problems/Assignment**

| | **Week 1** | **Week 2** | **Week 3** | **Week 4** | **Week 5** | **Week 6** | **Week 7** | **Week 8** | **Week 6** | **Week 9** | **Week 10** | **Week 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I am well prepared for this homework/assignment | | | | | | | | | | | | |
| I can identify the concepts/ideas useful for this homework/assignment on my own | | | | | | | | | | | | |
| I needed to discuss with my friends to identify the concepts/ideas useful for this homework/assignment | | | | | | | | | | | | |
| I completed the homework homework/assignment questions within the specified time | | | | | | | | | | | | |
| If you answered 'No' to the above describe the difficulties you faced and specific steps you will take to overcome them. | | | | | | | | | | | | |
| What changes in your knowledge have occurred after completing this homework/assignment **(Descriptive)** | | | | | | | | | | | | |
| Are there learning difficulties you faced in this homework? (Yes or no) | | | | | | | | | | | | |
| How do you intend to resolve them? What specific steps do you intend to take **(Descriptive if the answer to the above question is yes**) | | | | | | | | | | | | |

**Reflections on Lectures and Tutorials (Descriptive)**

**Concept Map**

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