Combining flipped instruction and multiple perspectives to develop cognitive and affective processes.

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INTRODUCTION

While the phrase ‘flipped learning’ may be relatively new it has been practised by some academics and teachers for decades. Flipped learning or as we prefer flipped instruction (as the learning should ideally occur at all stages of the process) is a form of blended learning that replaces transmission-based lectures with more participative, interactive and collaborative learning opportunities. Activities are typically undertaken before, during and after class, freeing in class time to participate in activities and engage with concepts at a higher level. Flipped activities should require students to engage in dialogue and include assessment (typically formative) to allow them to evaluate their understanding and progress in meeting the desired learning outcomes. Flipping creates an opportunity for academics to provide more dynamic and thus specific feedback to students, and to receive feedback from students about both the activities they are undertaking and what they don’t yet understand. Hence, the learning environment is socially constructed as academics and students combine to influence the nature, focus, complexity and timing of subject activities. Social cognitive theory provides a way to frame our thinking about this learning context by foregrounding aspects such as the environment created for learning, as well as considering development of student self-efficacy and how to scaffold the processes for this development.

This paper reports part of an ongoing study investigating relationships between engagement, goal orientation, affective outcomes and professional identity development in the context of flipped instruction. This study supported modification of our collaborative learning model [1] to explicitly provide multiple perspectives to assist students to overcome learning thresholds, develop disciplinary literacy, professional identity and expertise. In addition, it highlighted the impact of scaffolding and learning activity design on affective outcomes such as self-efficacy and includes the need for activities and assessments to be designed to enhance learning visibility. In this paper we report the impact of introducing multiple perspectives for problem-solving in a flipped instruction environment on students’ learning experience including any changes in the depth and/or method of learning, self-efficacy and professional identity development.

1 BACKGROUND

It is a commonly held misconception that flipped instruction leads to reduced contact hours and hence a reduced burden for both academics and students. Given that the idea behind flipped instruction is to fill the released class time with additional interactive and collaborative learning opportunities, when initially adopted, it often requires more effort from both. Instructors need to prepare more material and arguably understand it better, while students often have to modify their approach to one of more regularly learning (Fig. 1)

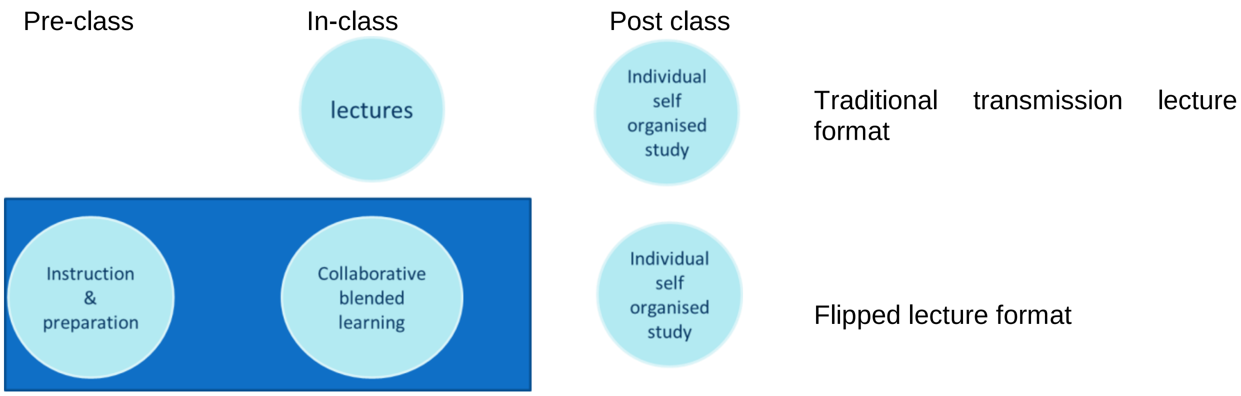

Fig. 1. Flipped instruction introduces additional learning opportunities/activities compared to the traditional transmission lecture mode.

Flipping often requires academics to develop new skills. For example in an engineering context it is common to characterise learning as being deterministic, sequential, using a single paradigm to solve a problem, arriving at a correct answer and this is how it is often taught and assessed. Engineering has also frequently embraced a culture of students following an expert, rather than finding their own way, leaving many without the confidence to exercise their own judgement. These factors have contributed to some students passing their assessments with little mastery of the material or development of the skills required for independent inquiry-based learning or solving more complex, open-ended problems.

Flipping should not simply be about changing the method of content transmission but an opportunity to significantly improve student development. We advocate that for academics to receive a reasonable return on the time and effort invested to develop flipped activities, they should teach the associated subject a minimum of three times. We suggest this for a number of reasons firstly; it is in subsequent semesters when developed material can be reused that a significant return on invested time can be achieved. Secondly, if the subject is new to an academic they usually require several cycles of feedback to evaluate and determine the best type of flipped activities to address any student difficulties with the subject learning outcomes. Thirdly, several cycles of teaching are often required for academics to develop different perspectives and deepen their understanding to the extent that they are sufficiently confident and prepared to effectively address issues raised in a less formal, open and evolving learning environment typical of flipping.

Flipping by its very nature helps instructors develop these skills by creating opportunities to receive more regular, ongoing feedback from students about the effectiveness of the academic's interventions and the activities they have designed for the students and what these students do or don't yet understand. For example as instructors walk around the classroom and listen to students' conversations as they collaboratively explore, solve, debate or discuss an issue or problem, common misconceptions become apparent. In answering these questions instructors have to first interact with students to identify what's causing their misconception or misunderstanding. These conversations frequently lead instructors to explain their reasoning from several different perspectives not only deepening their own understanding but practising and developing their capacity to help students learn, in ways that they may find, at least initially, uncomfortable.

These characteristics mean it is more difficult for an instructor to flip a subject that is new to them as opposed to one they have regularly taught before. Hence to provide time to develop the skills required for flipping we recommend that instructors start small, for example flipping one topic that students find difficult and use a combination of both observations and student feedback to improve subsequent activity design.

The jury is still out as to whether flipped instruction requires more work from students. What can be said is that it often requires a change in the approach, regularity, attitude and culture through which they engage in their learning. For example to participate in flipped learning opportunities students are required to continuously work throughout the semester rather than work only as summative assessments are due. Secondly our preliminary investigations have found flipped instruction often leads to higher level learning and a deeper understanding of the subject material, however as yet we have not determined the causation. Is it simply a result of more time on task (extra hours spent undertaking flipped activities), the collaborative more participative nature of flipped activities, improved learning effectiveness resulting from enhanced instruction and learning methods employed by instructors or that well-designed flipped activities actually provide some learning efficiency. We suspect that it is probably a combination of all these factors. However, we caution that poorly designed assessment will undermine learning irrespective of the quality of the learning opportunity.

The continuous work expectation combined with insufficient development of their judgement and self-efficacy are often cited as reasons for students not embracing or liking flipped instruction when first encountered. Self-efficacy, the belief in one's capacity to organise and carry out the actions required to achieve one's objectives [2], is important. Unless a student believes they have the capacity, including understanding, judgement or skills, to learn from flipped activities they are unlikely to have the incentive to engage and/or persevere when difficulties are encountered [3, p. 11].

Self-efficacy is developed through cognitive, motivational, affective and decisional processes [4]. In the context of learning and behaviour that facilitates learning, cognitive processes are developed by providing the student with an opportunity to encounter problems that require some effort to solve, and learning to "*manage failure so that it is informative rather than demoralising*" [4, p.13]. Motivational and affective processes are addressed through social modelling ie seeing other students succeed in solving problems, and social persuasion by for example defining success as self-improvement.

In part our intention for using multiple perspectives in problem-solving is to support the cognitive processes related to developing self-efficacy. Multiple perspectives help students to develop a complex knowledge base in relation to the subject area [5]. Multiple perspectives also make visible aspects of the phenomenon/problem that may not be obvious when using a single paradigm. In the problem-based learning environment Jonassen [6] recommends scaffolding these cognitive processes. We suggest that the motivational, affective and decisional processes required in developing self-efficacy will also benefit from scaffolding.

Hence if we want students to participate in flipped classrooms we need to provide scaffolding to assist students to understand how to make the most of these learning opportunities, including how to approach them, evaluate their learning, develop their judgement and the required learning skills.

At the very least an instructor should use scaffolding to create a learning-focussed environment motivating students to undertake activities with a focus on learning. In developing scaffolding we recommend that a good place for instructors to start is to explain to students [1]:

- why they designed the activity the way they did.
- what learning opportunities the activity provides the students
- how students can evaluate their learning from the activity
- how the activity is going to impact on their reality (enable them to see the world differently)

In addition we recommend that instructors take the opportunity to improve the visibility of learning when designing their activities to support the affective processes of self-efficacy, motivation and professional identity development. Students need regular opportunities to not only evaluate their learning but to appreciate how much they have learnt. This can be achieved by facilitating comparison of early understandings to those achieved later in the semester. For example through pre-and post-activity formative assessments or describing what students will be able to do and subsequently demonstrating how each activity has contributed to the overall learning objective.

1.1 Motivation for this study

In earlier studies we developed a collaborative learning framework first reported by the authors in [1]. Subsequently we have added a multiple perspective element to assist the learner's transition from novice towards expert. An expert views problems from multiple perspectives considering how best to solve them, evaluate their solution, identify sensitivities and weaknesses and can apply these perspectives in different contexts. In contrast a novice often uses only one approach or perspective to solve a problem. Given our intention to assist students to become more expert in all aspects of their development we propose providing opportunities for them to practice and evaluate the impact of applying multiple perspectives to situations and problems. Hence we modified our framework to include the introduction of multiple perspectives as shown in Fig. 2, in addition to the important steps of variation and confirmation.

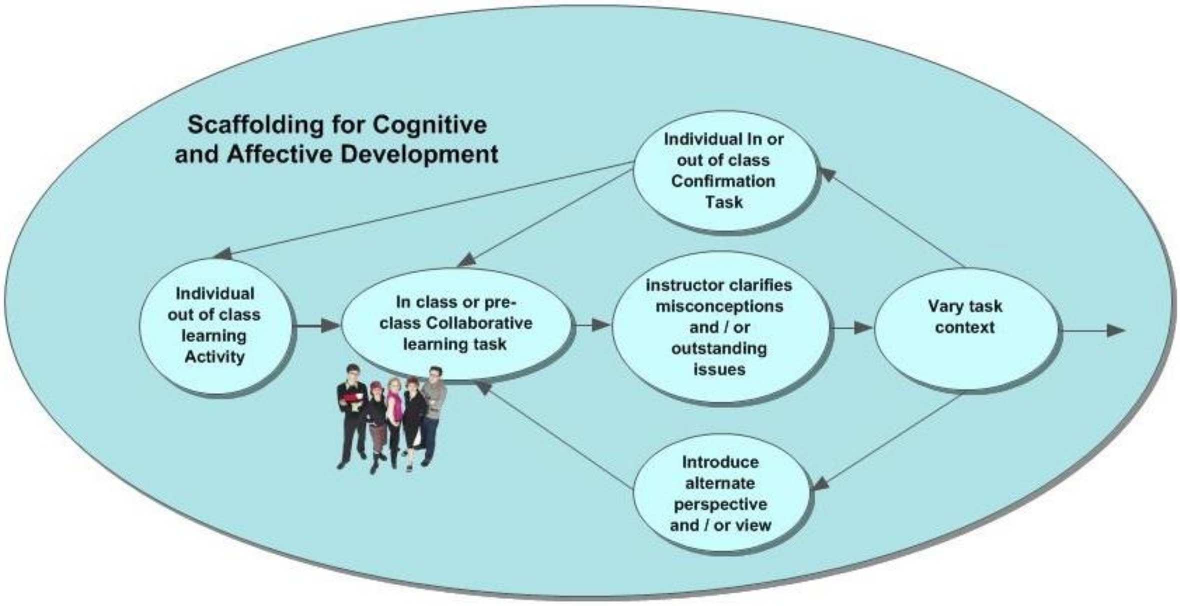

Fig. 2: Collaborative Learning Framework V2 as implemented in Continuous Communications in February 2014.

We design our learning activities to allow students to exercise their own judgement and to compare and discuss their understanding with their peers before academic intervention to clarify any remaining misconceptions. We do this as we previously found some students on receiving an answer from an instructor accept it without question, discontinuing discussion and hence don't use the opportunity to test their own judgement. This inhibitsdevelopment of their self-efficacy and hence capacity to transfer their learning to different contexts.

We also make extensive use of formative activities. Formative activities free students from the burden of strategically collecting marks and encourage a focus on learning. They provide opportunities for students to practise and get it 'wrong' helping them to identify their learning gaps and have them addressed before demonstrating their learning in summative activities. This also allows students opportunity to appreciate how mistakes provide information for further problem-solving attempts supporting the cognitive processes that develop self-efficacy [4].

The motivation for this research is our assertion that flipped instruction will free up contact time to undertake activities specifically designed to develop both student's cognitive and affective processes that would not be practical or promoted in other forms of instruction. In particular, our intention is to explore the impact of flipped learning activities designed to introduce multiple perspectives in problem-solving on students depth of understanding (cognitive) and self-efficacy, identity and motivation (affective). We investigated this in the context of students undertaking flipped instruction for the first time.

2 METHOD

Continuous Communications is a stage 6 (of 8) Telecommunications subject within the Information and Communication Technologies (ICT) Engineering degree at the University of Technology, Sydney (UTS). In autumn semester 2014 the first author taught this subject for the second time. The subject content was delivered through a combination of a series of short videos (19 in total, approximately 5 minutes in length, 15 specific content, 4 in the form of online demonstrations), notes, inquiry based learning activities and a series of formative individual and collaborative assessments. The videos intentionally did not cover all the content but rather targeted the more difficult and/or threshold concepts within the subject. The subject outline clearly identified the required learning outcomes and competency objectives of the subject. In addition, students were expected to consult one or more of the many textbooks available on the subject material.

The weekly format combined out of class readings, formative individual assessments, inquiry-based learning activities and online video presentations, with in-class formative collaborative assessments and /or learning activities.

The in-class activities were designed as opportunities to engage with the subject material at a higher level as opposed to introducing additional content or an opportunity to do tutorial work. That is, the activities were designed to engage students at the higher levels of Bloom's taxonomy, to analyse, evaluate and create, rather than to simply understand or remember. In addition the activities were designed using the updated collaborative learning process shown in *Fig. 2.*

The class was small, having only 21 students, although senior students, all were undertaking flipped instruction for the first time. Their perceptions were investigated through observation and informal discussion while seven students agreed to participate more formally including completing a survey containing both multiple-choice and free response questions. The focus of the discussions and the survey questions was on understanding the impact of introducing multiple perspectives for problem-solving on students' learning experience including any changes in the depth and/or method of learning, self-efficacy and professional identity.

3 RESULTS AND DISCUSSION

In Continuous Communications, the subject used in this study, students were expected to undertake out of class preparation including readings, watching videos, individual quizzes and enquiry based laboratory preparation. The in-class participative activities included collaborative multiple attempt quizzes, enquiry based discovery activities, discussions, laboratories and demonstrations.

Cognitive Impact

To explore the impact of both viewing and solving problems using different perspectives on student's cognitive processes they were asked about the impact on their perceived understanding of the subject material. Five of the seven students who volunteered to participate in the study agreed that compared to other teaching approaches they had encountered, engaging with multiple perspectives had helped them to:

1. **gain a deeper understanding of the subject material**. Their explanations included:

   "to understand a concept clearly is to have the ability to understand the concept under different perspective, if you can only see it from one perspective, it means you only have limited understanding and ability to solve problems"

   "Sometimes I find it difficult to translate the maths into an understanding of what is actually going on. The circuit explanations (one of the perspectives provided) *were used as nice examples";*

2. **more easily understand difficult and / or non-intuitive concepts,** their reasons included:

   Sometimes I *"find it difficult to translate the maths into an understanding of what is actually going on different perspectives allowed me to gain a rounder understanding of problems, which made them easier to understand".*

   I was *"able to understand concepts that previously looked complicated, easily by conceptual explanations and understanding it from different perspectives";* and

3. **develop a deeper understanding of the theory behind concepts,** commenting that:

   "instead of just learning to solve problems the approach helped me develop a deeper understanding of the subject material"

   In other subjects I could *"get through the Maths … but often found it difficult to explain or understand what was actually happening to the signal"* this approach helped me see what was going on.

Affective Impact

To explore the impact of using multiple perspectives on student's affective processes they were asked about the impact on their confidence, identity and motivation for engineering.

Six of the seven students who participated in the study agreed that practicing using multiple perspectives to solve and examine problems had:

1. **given them confidence that they will be able to solve the type of problems they expect to encounter as a graduate engineer, developing their self-efficacy**, one student commenting that:

   "solving problems using multiple perspectives gave me a confidence boost";

2. **helped them see themselves as an engineer developing their discipline identity**. When asked what about the process supported their view, students explanations included:

   "I could see myself solving these type of problems"

   "having real-life examples is most beneficial to students. Explaining a range of real-life scenarios rather than just teaching ohms law for example shows how the theory and practical application merge"; and

3. **increased their enthusiasm for engineering improving both their self-efficacy and learning motivation** one student commenting that this approach has made them want *"to solve more problems".*

Students also reported that the flipped design fostered the affective processes that support learner independence and self-evaluation commenting that:

"I had to depend on myself more"

"it helped to review knowledge easier and determine how much I had achieved".

One student went so far as to advocate that they wanted more learner independence suggesting that we *"don't provide solutions to problems just the answer so that students can work their way to the end by themselves"* this was despite the fact that we only provide solutions to about 20% of the problems used in the learning activities.

Hence an attraction of flipped instruction is that it provides time to pay attention to affective factors such as identity and self-efficacy reported by Adams as having the potential to:

"...empower and strengthen aspiring and future engineering professionals to pursue, succeed, and find fulfilment in engineering. Thus, investment in instructional practice to improve affect ...is an essential part of engaging the future engineer...." [7 p.58].

We would argue that instructors should make the most of this opportunity and incorporate activities to address affective factors in their learning design, not simply focus on improving cognition or face-to-face and/or real estate (reduced time in classroom) efficiencies.

Ongoing Issues

Despite the overall positive flipped experience of students they did identify a number of issues that we need to be aware of for the next implementation.

One student reported that they had a problem with group sessions as *"students progress at different rates"* and that *"a group may sometimes have achieved the learning goal giving a false sense of individual achievement"*. The latter comment is concerned with what we have previously referred to as "collective ability" [8, 9] where students as strong contributors to a collaborative learning activity appear to understand the associated learning outcomes. However, without the support of their peers, gaps in their understanding became evident. In our earlier studies we found that the individual confirmation task shown in *Fig. 2* was an important factor in addressing collective ability. However, our latest research suggests that premature closure is a contributing factor.

In previous studies we used activities that in effect terminated when students arrived at an answer. This often closed their thinking, as they reasoned that solving the problem meant that they understood all they needed to know. In this study flipped instruction freed up class time to introduce activities that go further by exploring and understanding problems from different perspectives. We also deliberately placed an emphasis on explaining and understanding why alternative solutions that often appeared reasonable were incomplete or incorrect. The results suggest that problems/issues/solutions are explored more thoroughly when a learning activity is developed using a combination of variation, multiple perspectives, explanation of alternatives and confirmation (see Fig 1) and achieving a level of understanding not a correct answer signals the conclusion of an activity. This approach promoted deeper learning and a reduction in collective ability. However, if students only undertake surface level engagement for example choosing not to do their pre-work and/or remain satisfied or focused on simply achieving the correct answer, learning outcomes will typically be poor irrespective of how well the activity is designed. This emphasises the responsibility of both academics and students to achieve optimum outcomes in what is essentially a socially constructed learning environment.

This view was supported by a student who suggested that the success of the current design was largely dependent on students' engagement with it commenting:

"since we prepared before class, it developed more understanding the concept and see the difference what we understand and what the actual things do...if we don't prepare for the material before the class, we don't catch up anything in the class".

As designers we acknowledge that student engagement is integral to their learning success. As instructors we found that flipped design makes it more obvious which students are engaged and the level of their engagement, compared to the traditional transmission-type lectures where it may seem that because students appear to be paying attention they are on top of the material.

As discussed earlier well designed scaffolding is important in promoting student engagement. In our scaffolding we advocate that *"mistakes compress learning*" and that students should push their learning boundaries until they make a mistake or discover what they do not know and then address these issues through individual discovery, discussion with peers or if necessary the instructor. One respondent articulately voiced their disagreement with this philosophy, commenting that:

"*I don't believe learning from mistakes is the best way to organise learning, it should be avoided if at all possible"*

This suggests to us that in regard to scaffolding at least, we have more to do.

In this exploratory study we found that flipped instruction freed class time to introduce participative activities designed to develop student's cognitive and affective processes. We also found evidence that introducing multiple perspectives in problem-solving not only had potential to contribute to students' transition from being novice towards more expert but also assisted in developing their self-efficacy, professional identity and motivation for engineering.

4 CONCLUSIONS

Although flipped instruction has significant potential to improve learning outcomes, this does not occur without the commitment of additional time, resources and skills development on the part of academics and a change in learning culture amongst students.

Supportive scaffolding is required to assist students to develop the skills and attitudes required to make the most of flipped instruction. We suggest such scaffolding is an important characteristic of good design in facilitating an environment that provides opportunities for mastering the content and developing aspects of self-efficacy.

The main affordance of flipped learning is the opportunity to free up class time to allow participative learning opportunities not merely as a means of changing information transmission from face-to-face to online. The results of this exploratory study indicate the value of using multiple perspectives to develop understanding of subject concepts and the formation of affective factors such as self-efficacy, motivation and professional identity development.

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