

Introducing student-centred, collaborative tutorials in *Advanced Mathematics*

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Abstract

The current status of *Advanced Mathematics* teaching in the University of Guangxi is introduced. Some problems of the traditional way of teaching are discussed and some changes are suggested.

Introduction

In the University of Guangxi (and most of the universities in China), *Advanced Mathematics* is a compulsory course for all first year science and engineering students (except for those students who will major in mathematics). It is a two-semester course and covers limits and continuity, calculus, vector space and analytical geometry, multi-variable calculus, infinite series and ordinary differential equations. The objective of this course is to enable students to understand basic mathematical concepts, equip them with necessary mathematical tools and foster their abilities to use these concepts and tools in other disciplines.

There are three levels of *Advanced Mathematics* corresponding to different disciplines. Level 1 is for physics and most engineering students, covering all the content mentioned. Level 2 is for chemistry, chemical engineering and life science students, covering less content than Level 1. Level 3 is for students who will major in agriculture and does not cover vector space and multi-variable calculus. Level 3 is a one-semester course.

In the University of Guangxi, students from the same discipline form a class. The number of students in each class varies from 50 to 120. About 20 lecturers teach *Advanced Mathematics*. The teaching/learning process is traditional. Each semester there are about 100 hours of lectures in *Advanced Mathematics*. This means 6 hours of lectures each week—either two 3-hours lectures, or three 2-hours lectures. Students need to complete an assignment after each lecture and hand it in at the beginning of the next lecture. There is no specific tutorial. Teachers usually give a 'tutorial' at the end of each chapter. The so-called tutorials have the same number of students as lectures. Tutors give a summary and students do practise questions and drills.

At the end of each semester, all the students from the same level have the same closed-book examination. 70% to 80% of the final mark comes from the examination, 20% to 30% comes from the assignments.

Why do we need change?—problems with the current way of teaching

Although most lecturers are enthusiastic about their teaching and try to make lectures interesting, the outcome is not always satisfying.

Each semester more than 30% of students fail this course. Students feel that it's a big burden to pass *Advanced Mathematics*. Many students learn by rote. They try to copy everything from the blackboard and imitate what tutors have done in the tutorial. Many of them complain that they can't follow the lectures and the assignments are too hard.

Lecturers always complain that students lack the abilities of analysing and thinking. But almost all of the lecturers still use a 'spoon-feeding' approach, since otherwise students will complain that they are not teaching very well.

Teaching/learning activities are important and must be aligned with the course objective to achieve the learning outcomes. When we do not achieve what we expected, changes are necessary.

Student-centred collaborative learning

Student-centred learning means that the student (learner) is put at the focal point of the teaching/learning process. Collaborative learning 'is an umbrella term for a variety of educational approaches involving joint intellectual effort by students, or students and teachers together' (Goodsell, Maher, Tinto, Smith and MacGregor 1992). Student-centred, collaborative learning is based on the constructivist learning theory.

According to the constructivist learning theory, students are always the key players in learning activities. Quality learning is most likely to happen when it is student-centred. Research (Lagowski 1990) shows that students retain: 10% of what they read; 26% of what they hear; 30% of what they see; 50% of what they see and hear; 70% what they say; 90% of something they say as they are doing it.

Constructivist learning theory also suggests that quality learning is most likely to happen when it is cooperative in nature rather than competitive because people do not learn things best at the expense of others. Since learning is essentially a human activity, it is more likely to occur when it is a social act, shared with peers and validated by the whole learning environment.

Although constructivist theory has not been widely used in college mathematical teaching/learning processes, researchers have found many advantages in student-centred, collaborative learning. Mathematics is more fun and students' interest in mathematics is increased when the students work in collaborative groups. 'A majority of students found the collaborative tutorials interesting and enjoyable, and even larger number of students agreed with the statement that they thought the collaborative tutorials improved their mathematical understanding' (Oates 1999). Collaborative learning fosters the development of critical thinking through discussion, clarification of ideas, and evaluation of others' ideas (Gokhale 1995).

What will be done?

Some changes in tutorials will be made to provide a student-centred, collaborative learning environment.

The way we give tutorials should be the first change. We need to make the tutorial a place where students think and understand rather than a place to imitate and memorise. We also need to select or design proper problems for students to discuss and develop their critical thinking ability. The problems should be interesting and accessible for the students. They might be complicated but realistic, open-ended, even ill defined to help students construct their deep understanding in *Advanced Mathematics*. Here is an example of a problem (Hughes-Hallett, Gleason and McCallum 2001).

The graph shown in Figure 1 is a record of a hot-air balloon. The graph shows its vertical velocity, v , with upward as positive.

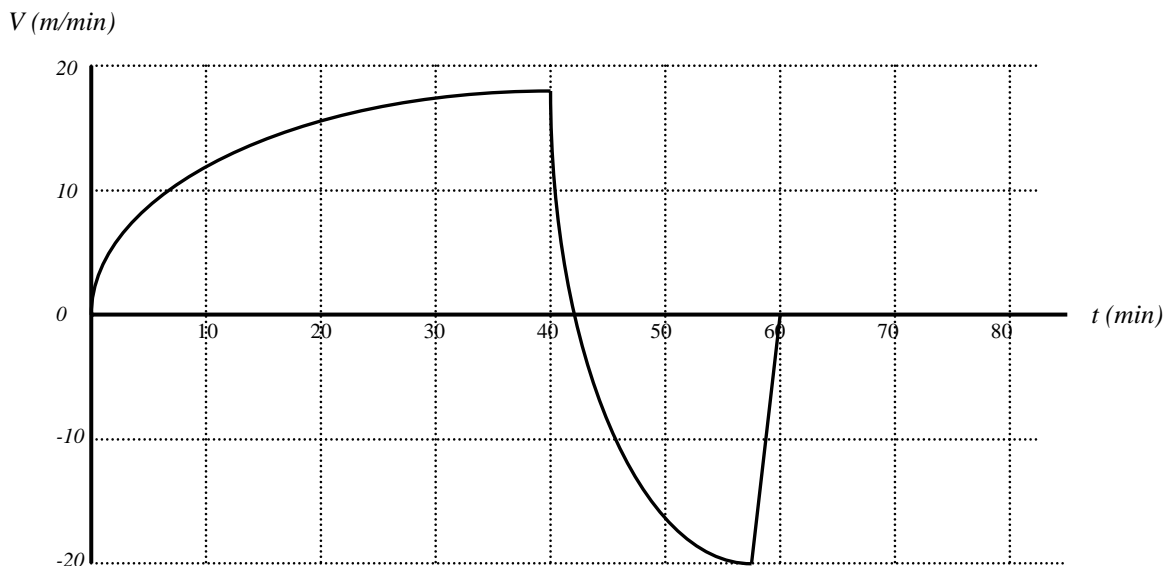


Figure 1

- (a) Over what intervals was the acceleration positive? Negative?
- (b) What was the greatest altitude achieved, and at what time?
- (c) At what time was the acceleration greatest?
- (d) At what time was the deceleration greatest?
- (e) What might have happened during this flight to explain the answer to part (d)?
- (f) This particular flight ended on top of a hill. How do you know that it did, and what was the height of the hill above the starting point?

This problem is interesting, realistic and open-ended. It does not look like traditional mathematical problems because it has no mathematical symbols. However through discussing this problem, students can develop deep understanding of the concepts of derivative and definite integral. From this kind of problem students can also see how mathematics relates to the real world, and they can learn to use mathematical language to interpret why things happen.

We can also change our lectures by including in-class discussion groups. This can be done by dividing big lecture classes into several smaller tutorial classes. Within the tutorial classes, we could ask students to form several groups and encourage them to discuss problems with each other.

We could also encourage out-of-class study groups as an extension of a tutorial, and ask students who live in the same dormitory (about six students) to form a study group encouraging them to continue their discussion after class.

If it is possible, we could also increase tutorial times and reduce lectures times.

Difficulties and barriers

While collaborative learning has been proved successful in many other universities, there are still some difficulties.

One is that there are some students who do not like collaborative learning. In China this proportion may be greater because Chinese students are used to competing rather than cooperating with each other. School and college teachers encourage students to solve problems independently. Some teachers turn up their noses at students who can't do their assignment by themselves. Most first year students may not have much experience in active learning. They are used to a 'tell me the answer' spoon-feeding approach.

A second problem is how to choose or design problems for students to discuss and encourage them to think critically. If what the students do in a collaborative tutorial is just practise questions and drills, then the advantages of collaborative learning may not be significant.

Thirdly, in the University of Guangxi there are very few classrooms suitable for collaborative learning. All the facilities in a classroom are fixed. It is difficult to change the arrangement of a classroom.

Another barrier is the cost, both in money and time. If a large tutorial class is divided into several small ones, more tutors will be needed, and that requires more money.

Designing suitable problems for collaborative tutorials to keep the tutorial dynamic is time-consuming.

Finally, the assessment system would need to change. Under the current assessment system, most students want to spend more time practising model examinations in order to pass final examination. Student-centred, collaborative learning may not increase examination marks. 'Implementing collaborative learning is a complex process. The benefits are usually long term rather than having instant effect.' (D'Souza and Wood 2003) If the university does not change the assessment system, both students and teachers will be reluctant to change the existing teaching/learning approach.

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