

A framework for teaching excellence in the context of university mathematics education

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In this paper, I propose a framework for teaching excellence in mathematics, particularly in the context of universities. The framework encompasses four aspects: module learning outcomes, lesson plan, teaching modes, and motivational strategies. Through this framework, I will share with readers my view on various aspects that a math teacher should pay attention in order to excel in his or her teaching.

Regardless of subjects and levels, education is made up of three components: *curriculum*, *teaching* and *learning*. In the university context, the curriculum of a program is typically developed at the departmental level; the teaching is delivered by the lecturers, instructors or teaching assistants; and the learning comes from the students. Although the three components are acted upon by three distinct groups of people, they are clearly inter-related (Figure 1). This three-way structure is similar at the school level. In the Singapore local school context, the curriculum is developed by the Ministry of Education.

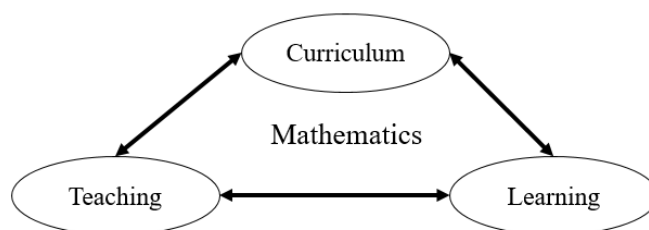


Figure 1. Three components of mathematics education

Generally speaking, as long as it aligns with the university's educational direction, the department has the liberty to develop the curriculum for its program independently. This includes the program requirement, structure and study plan. The department also looks at the syllabus and prerequisites of individual modules. The component that I will be focusing on is *Teaching*, in particular at the module level.

A Framework for Teaching Excellence

The lecturer, who is usually also the module coordinator, needs to define the *module learning outcomes* (MLO) based on the syllabus. Guided by the learning outcomes, the lecturer will proceed to design the module. This entails coming up with the lesson plan and deciding on the teaching and assessment modes. At a micro level, the lecturer and the TA can also do the same for every single class he or she conducts.

Although the learning component mainly comes from the students' own initiative, there are various aspects that the teachers can facilitate the learning process. Other than transmitting the knowledge and assessing the students, teachers can engage the students by asking questions and providing feedback to them. Another important aspect that I will elaborate is to come up with strategies to motivate student learning.

I would like to propose a *Framework for Teaching Excellence* (Figure 2) at the module level. The framework takes the form of a pyramid. At the tip of the pyramid is the *module learning outcomes* (MLO), which is the ultimate goal that every module should strive to achieve. The other three layers of the pyramid which contribute to reaching the MLOs are having a sound lesson plan, adopting teaching mode that will engage the students, and coming up with effective strategies that motivate student learning.

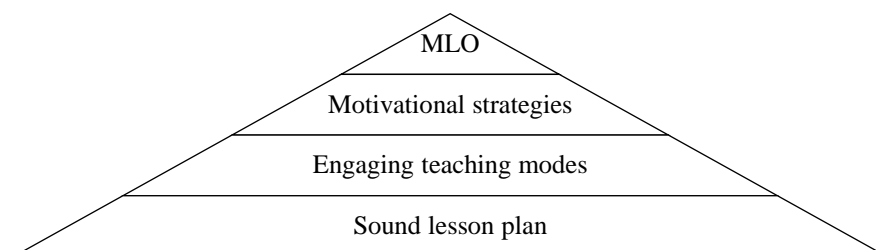


Figure 2. Framework for Teaching Excellence

Module Learning Outcomes (MLO)

All good teaching should come with a set of learning outcomes that are clearly articulated and communicated to the students. Good MLO should not just narrowly focus on the concepts within the syllabus that students are expected to learn. It should also include other higher order learning, such as applying the concepts within and outside the module, integrating the concepts within the module, and seeing connection of the concepts beyond the module. The teacher should then develop and design the module with the MLO in mind.

Lesson planning

The bottom line in the module design is to have a lesson plan. Lesson planning is generally quite straightforward – as long as it is aligned with the MLO. A *sound lesson plan* is comprehensive and has more than just a list of the topics to be covered for each lesson. It should be supplemented with in-class and outside classroom activities that enhance student learning. For example, a good teacher will pay attention to the difficulties that students have and address them adequately by allocating more time to illustrate with additional examples or the use of analogies to illuminate the concepts. On the other hand, easier concepts or topics can be left as assignment for students to read on their own. Teachers should also surface common mistakes, misconceptions, and other pitfalls among the students. Though it is more direct for the teachers to highlight them to the students, it is more effective to design some examples or problems for students to self-discover their own mistakes. Furthermore, assessments should be an integrated part of the lesson plan. Other than the traditional summative assessments, like tests and examinations, formative assessments in the form of quizzes, assignment, and group work can also be introduced to gauge students' understanding of the concepts and to make the lesson more interactive.

Teaching modes

There are several modes of teaching that teachers may choose to adopt, ranging from the traditional face-to-face (F2F) “lecture + tutorial” format, to blended-learning, to flipped-classrooms – which teaching mode to adopt depends on the nature of the classroom activities. Due to Covid-19 restrictions, many F2F classes have been converted to online classes,

typically delivered through video-conferencing platforms (e.g., Zoom, Microsoft Teams). The module coordinator should also take into consideration the students' level of understanding of mathematics, class size, and nature of the modules, together with other constraints, when choosing the appropriate mode of teaching. The question is not about whether flipped classroom is better than traditional lecture – it is about whether a teaching mode can effectively engage the students with the intended lesson plan.

The key word is “engaging”. If most students in a class are highly motivated or high-ability students, the teacher may consider replacing live lectures with fully flipped classes. The students can be challenged to read the notes or textbook independently. This should be complemented with some interactive activities such as discussion or seminar-styled sessions. On the other hand, if a class mainly consists of students with weak mathematical foundation, for example a bridging course, then an interactive F2F class may be more suitable to gauge the students' understanding and to provide instant clarification. More commonly, there are students with diverse aptitude and backgrounds in the class, typically found in foundational courses like calculus or linear algebra. The lecturer can consider a hybrid mode in this case. One approach is to prepare lecture materials (can be in the form of pre-recorded videos) for the students to read or view in advance. This is then followed by F2F sessions for the lecturer to further elaborate on the more difficult concepts. Such sessions can be made optional just for the weaker students. Nevertheless, if a teacher can find the right balance to engage all the students in class regardless of their backgrounds, such sessions can also be made compulsory if they help to meet the MLO. A lecturer should also take into consideration the short attention span of the new generation of students when choosing their teaching modes.

Motivational strategies

To complete the puzzle of excellent teaching, learning must take place among the students. As much as we hope that all students will be self-motivated with their learning, the reality suggests otherwise. No matter how hard a teacher tries to explain the concepts, if the students are not motivated to take the learning seriously, the MLO will not be met. It is therefore essential for good teachers to develop some strategies to motivate student learning.

We are mainly concerned about two groups of students: the first group are those that are not motivated and typically only study near the exam date; and the second group are motivated solely by the exam grades. For the first group of students, it is definitely undesirable for them to cramp the learning of mathematics within a few days. There are diverse reasons for their behaviour. For some, this may be caused by not being able to follow the class or not seeing the relevance of the module. For others, they may be simply unimpressed with the teaching, while some are simply not interested. The teacher should identify the more common reasons and come up with appropriate strategies to address them. Giving support, encouragement, and feedback to the students will definitely help. Rewarding with points for constant work can also be an effective strategy.

The second group of students can be very hardworking. Some may even approach the teachers for more exercise problems or past year papers to practice. The concern here is superficial and rote learning. The lecturers could guide the students to see the big idea and provide them with the insights. They could also advise students to slow down and do some reflections and analysis of their own works instead of rushing through as many problems as they can. Once the students are enlightened, they will become genuine learners and will be motivated to go deeper to explore the subject.

The Framework for Teaching Excellence in Action

I shall now illustrate the Framework for Teaching Excellence in action with an example from the NUS mathematics program (Figure 3). In the university program, most modules are inter-related by prerequisite trees:

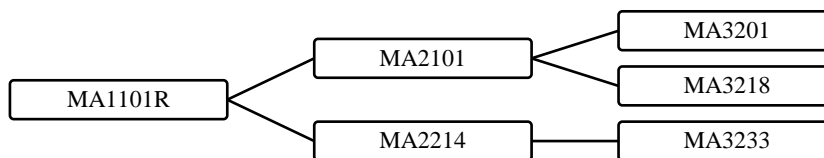


Figure 3. An example of a prerequisite tree

The module MA1101R (Linear Algebra) is the prerequisite for the two level 2000 modules MA2101 and MA2214, which in turn are prerequisites of some other level 3000 modules. In other words, the lecturer teaching MA3201 may assume his students already know the concepts taught in MA1101R and MA2101. However, it is rather common to hear colleagues lamenting about their students being clueless about concepts that they were supposed to learn in the prerequisites. We are quick to blame the students. They learned the module and they passed the exam, but they are not able to apply or connect what they have learned beyond the module. The lecturers who teach those prerequisite modules could also reflect on how to address such issues.

Using the Framework for Teaching Excellence, a lecturer can make it explicit to include in the *MLO* that require students to “apply the concepts beyond the module”. This serves as a message for the students to see the larger objective of the module. But more importantly, by making this learning outcome visible, it also reminds the lecturer to design the module with this end goal in mind. Conscious effort can be made to build in some class activities or assessments in the *lesson plan*. For example, a mini group project with the task to look for some applications of the concepts that are not found in the module. Through appropriate *teaching mode*, the lecturer can convey the message in his or her instructions. In particular, to serve as a *motivation*, the lecturer may give a preview of how some of the concepts will be relevant in future courses.

The above example illustrates the importance of MLO in the framework to guide the module design. The example also suggest how to formulate higher order learning outcomes beyond the topics to be covered.

Concluding Remarks

I have briefly discussed some aspects of good practices in teaching excellence, mainly for mathematics education. An excellent math teacher needs not be someone who is charismatic and eloquent. He or she must be one who is sincere in the teaching and willing to put in time and effort in crafting the MLO, designing the module, as well as motivating and supporting student learning.