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In this issue of CDTL Brief *on* ***Learning with Technology****, the authors discuss how to use some Integrated Virtual Learning Environment (IVLE) features to enhance students' learning and understanding of the subject.*

Root Questions for Large Classes

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While lecturers teaching large undergraduate classes often face the critical problem of efficient and effective continuous training and assessment, undergraduate students in the School of Computing at NUS struggle with a busy timetable, juggling numerous deadlines for homework, assignments and other projects. Hence, their lecturers need to look for valid and reliable continuous training and assessment strategies that can be marked quickly and provide immediate feedback.

Potentially, some ICT tools can automate part of the training and assessment strategies, make the process efficient for lecturers and offer flexibility to the students. Ang (2004) recognises that the use of ICT tools can help overcome many of the training and assessment problems associated with large classes. Yet Ang (2004) also acknowledges that most existing courseware management systems do not provide effective tools for online continuous training and assessment, especially for large classes.

The Integrated Virtual Learning Environment (IVLE) in NUS is a fully-integrated set of high quality management and communications tools. Features such as discussion forums and feedback surveys are excellent teaching and learning aids even for large classes. IVLE includes in particular, an online assessment tool that comes with seven different generic types of questions: 'Multiple Choice', 'Multiple Response', 'Select List', 'True or False', 'Fill in the Blank', 'Matching' and 'Essay' questions. All but the last type of question can be marked automatically. Unfortunately most of these types of questions are better suited for summative forms of assessment than formative ones although there are creative strategies to use these types of questions for effective formative assessment (see for instance, Zubair & Khoo, 2003).

Online assessment with root questions* was introduced during Semester 1 of Academic Year

* The examples of root questions mentioned in this article are taken from Ullman (2005). Further discussion on the design of root questions and more sophisticated examples are available in Ullman's paper. The Gradiance system (http://www.gradiance.com/PH/servlet/COTC) currently offers instructors and their students a free online access to a bank of root questions in the areas of databases, compilers, automata and language theory, and operating systems. Instructors can request access to the system and its bank by sending an email to support@gradiance.com. Instructors who wish to contribute root questions in these or other domains can send their contact to the Gradiance team at the same email address.

2004/2005 for the module CS2102 "Database Systems". The designed and proposed root questions covered topics such as relational calculus, theory of functional dependencies and normalisation of relational designs. Since the main objective of the assessment was formative, students were given sufficient time for multiple attempts. Students generally found this form of assessment more flexible than the traditional assignment.

A root question is a multiple choice question that has several right answers and many wrong answers. It comprises a stem, a few correct choices, several incorrect choices, a solution and choice explanations. The stem is a statement of the problem presented to the student. The student is asked to identify the set of solutions to the problem from a list comprising a few correct choices and several incorrect choices. The list is generated every time the student attempts to answer the question. The incorrect choices are usually designed to reflect typical mistakes with explanations to help clarify the student's doubts. Alternatively, the explanations can also be replaced by hints. The solution to the problem with an explanation is presented to the student when the homework deadline is reached.

The student will see a different set of choices every time he/she attempts the question. Thanks to the choice explanations and hints, the student quickly realises that the best strategy is to solve the problem given by the stem rather than trying to guess the correct choice. In addition, he/she can learn from making incorrect choices. Such a learning process transforms a standard multiple choice question into a problem-based learning experience. Thus, root questions not only allow for the process of assigning and grading to be automated, it also enables a problem-based approach to the assessment.

To illustrate the notion of root question, let us consider a simple example in the domain of integral calculus. Our goal is to make sure students understand the rule for integrating polynomials (e.g. $\int x^n = x^{n+1} / (n + 1)$). A conventional problem would be something like:

> Compute the indefinite integral of $20x^4 + 12x^3 + 30x^2$.

To turn this question into a root question, we need to observe that there are three terms to this polynomial and so there are three natural components that lead to three correct choices. If we wanted more choices, we could add more terms to the polynomial. Thus, we can phrase the root question as:

> Compute the indefinite integral of $20x^4 + 12x^3 + 30x^2$. Then, identify one of the terms in the integral from the list below.

Since there are three correct choices in this example: $4x^5$, $3x^4$ and $10x^3$, we should develop approximately nine incorrect choices by using some common mistakes that students might make, and with explanations. In this example, one common mistake students often make is to forget to divide by n + 1. This mistake leads to the incorrect choices of $20x^5$, $12x^4$ and $30x^3$. Another possible mistake is to divide by n instead of n + 1 and thus students might choose $5x^5$, $4x^4$, and $15x^3$. We could proceed by theorising about other possible errors, or just add some random, plausible looking incorrect choices such as $3x^3$, $60x$, $80x^5$ and $6x^3$. We now have three correct and 10 incorrect choices to make a reasonable combination.

The explanation will point out the mistake for incorrect choices designed to detect specific mistakes. For example, the explanation associated with an incorrect choice, $20x^5$, $12x^4$ and $30x^3$, might say:

> The correct rule for integrating polynomials requires that we divide the term by a constant. Do you remember how that constant is determined?

For the incorrect choice, $5x^5$, $4x^4$ and $15x^3$, the explanation might say something similar:

> The correct rule for integrating polynomials requires that we divide the term by a constant. However, you may have chosen the wrong constant.

These explanations jog the students' memory and help those who have already understood the idea

but were careless. Despite these explanations, some students might still feel lost. Hence, we might choose to attach to the remaining four incorrect choices more explicit advice such as:

> In order to integrate a polynomial, we integrate each term and sum the results. The rule for integrating a term is $\int ax^n = ax^{n+1} / (n + 1)$.

Interestingly, during the assessment period, groups of students spontaneously started to discuss the questions on the module's IVLE discussion forum. Such discussions should be encouraged as they play a similar role to the one of the choice explanations.

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Using Online Discussion Forum in Learning Mathematics

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Introduction

Discussion—sharing and articulating ideas—is an important part of the learning process, especially in tertiary education. Through discussion, learners can discover their misconceptions which they may not realise otherwise and thus enhance their understanding of the subject. Discussion in class also helps the teacher understand problems students face in their learning. Since it is common for students have a different perspective from the teacher, students can learn better if they have to explain or clarify certain concepts to one another. Thus, discussion facilitates peer learning.

Unfortunately, in Singapore, math classes at the tertiary level are usually very quiet. Though this is understandable in a big-class math lecture, students do not speak up even in small tutorial or discussion sessions. At best, students only come up to the whiteboard to reproduce the solutions they have prepared in advance.

Why are math classes so quiet?

The main reason students feel uncomfortable about discussing during math classes is because they find it intimidating to speak up in front of a group of people, especially when they have not known one another well. The weaker students in particular, have little confidence to speak up in front of the better ones because they are not sure whether they are asking 'stupid questions'. The better students also tend not to speak up as they do not want to be 'showing off' or arrogant. Another reason local students do not discuss in math classes is because they have been accustomed to just copying solutions during math classes in their earlier education. When the students come to university, they expect that math classes would be conducted in same way and

some have found it hard to adjust. Thus, teachers need to create an environment conducive for students to discuss math in class. However, it would not be easy to students overcome their psychological barrier.

Online discussion forum

I have discovered that one way to 'break the ice' among students is to use the online discussion forum on the Integrated Virtual Learning Environment (IVLE). This mode of discussion allows even the shy students, who are fearful of face-to–face discussion to discuss math with their classmates. The IVLE discussion forum allows students to:

- Use plain text, hyperlinks, tables, graphics and math symbols in their postings,
- Attach a files of up to 15MB in each posting,
- Be notified when there is a response to his or her posting, and
- Be anonymous by displaying only students' nicknames.

There are (at least) four ways to write mathematics on the IVLE discussion forum:

- Use simple symbols or notation and type them 'linearly' as plain text. If all the students in the class know some common math software (e.g. Maple), they can input math in the discussion forum the same way they will input math in Maple,
- Input standard symbols and notation using the equation editor which can be accessed via the toolbar located on top of the message window,
- Typeset more complicated equations or less common notation using some convenient software (e.g. LaTeX) and then convert them into graphic files and insert them in the desired position of the posting, and
- Prepare the whole posting in PDF (or other) format and include it as an attached file.

Advantages of online discussion forum

Initially there may not be many people posting on the forum, but if the discussion can be sustained, subsequently more and more students will join in the discussion. Generally, students find 'speaking up' on the online discussion forum less intimidating than face-to-face discussion. Another advantage that online discussion forum has over face-to-face discussion is that it does not limit the number of participants. Every student, no matter how big the class, can be involved in discussing a topic by viewing one another's postings and posting their own views.

Unlike face-to-face discussion, online discussion can be carried out anywhere anytime. Since face-to-face discussion usually requires real-time response, students who are weaker in math may not find this format beneficial to them. With online discussion forum, students can have more time to think through the argument and compose their responses. As hyperlinks of Web pages can be inserted into the posting, the discussion forum can also integrate Internet resources into the discussion content.

The IVLE discussion forum also allows the lecturer who creates the forum to get statistics on student participation. Table 1 shows the statistics of student participation in two of my modules, MA2101 "Linear Algebra II" and MA1506 "Mathematics II". Though less than half of the class for each module posted on the forum, such participation rates for a near-zero discussion math class do indeed have some positive effect in getting students to discuss math.

Table 1: Student participation in the online discussion forum for MA2101 "Linear Algebra II" and MA1506 "Mathematics II"

Modules	Class size	Forum format	% visited forum	% posted on forum
MA2101	250	structured format, assessed	90%	40%
MA1506	1500	free format, non-assessed	70%	20%

Limitations of online discussion forum

Ironically, one of the main criticisms of online discussion forums is the lack of face-to-face interaction. This highlights the fact that virtual

discussion cannot totally replace face-to-face discussion; there are certain advantages of direct interaction. Thus, I would like to suggest teachers use the two formats of discussion at different stages. For example, teachers may start off a new math class using online discussion to engage students in discussing math. Once students know one another better and become more comfortable with discussing math with their classmates, teachers may switch to real-time discussion instead.

Since the majority of students will visit the forum only to view the posts, the discussion forum for small classes with less than 100 students may die off after a while if there are not enough active participants. The discussion cannot be sustained if there are fewer and fewer students posting or even visiting. Large classes, however, have the advantage of a critical mass of active participants who will keep the discussion going. Large number of postings can elicit responses even from silent participants. However, one of the limitations of online discussion forums for large classes is that teachers may find it hard to use the forum as an assessment component.

Format of discussion forum

The following are some suggested ways of running an online discussion forum:

- Free format—Teachers may open up a forum and let students post whatever they want. For big classes, such a forum can get very disorganised if the teacher does not maintain it regularly,
- Structured format—Teachers may open topic-based forums (e.g. one discussion forum for each chapter or for each tutorial),
- Teacher-initiated format—Teachers may also initiate a discussion forum by posting some open-ended problems (related to what they are learning) to students,
- Group discussion format—Teachers may also use the forum for small group discussion (i.e. one forum for each group). If there are many groups, teachers may need to get additional facilitators to help monitor the discussion for each group, and
- Lecture feedback format—Most lecture theatres at NUS are equipped with wireless Internet connection and students carry laptops to class. Teachers can make use of the online discussion forum to collect instant feedback from students during lectures. This serves as a channel for discussion even in large classes.

Discussion as assessment

If the class size is small, teachers can include online discussion as part of the assessment by making it compulsory. The assessment criteria can be based on either the quantity of postings (e.g. every student must post at least three postings throughout the semester), or on the quality of the postings. But the latter criterion will be harder for the teacher to keep track if the class size is large. If the discussion forum is part of assessment, I suggest that its weightage should not be too high and the forum should be more structured and focused. I usually give students options to either participate in class or in the forum.

Teachers' involvement

When a teacher creates a discussion forum, s/he should monitor the forum closely. In my opinion, it is more beneficial for the teacher to participate in the discussion. However, some may argue that once the teacher gets involved, the discussion forum becomes a 'one way traffic' (i.e. students ask and teacher replies). This scenario can be avoided if the teacher acquires some techniques to facilitate the discussion. For example, when a student makes a wrong claim, the teacher should not jump in and correct him straight away. Wait and see whether the other students are able to point out the mistake. If not, then the teacher will chip in. But instead of simply telling the student the correct answer, the teacher may prompt the student to reconsider his claim or drop some hints to guide the student. Another reason that teachers should keep track of the forum is to identify some of the students' common misconceptions and clarify them in class. Last but not least, dropping a line to encourage students may just motivate more students to participate in the discussion. ■

Technology-mediated Learning—The Case for Macromedia Breeze and IVLE Tools

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Can computers ever replace face-to-face teaching? This million-dollar question lends itself to rhetorical contentions, driven by the shifting contextual flux of the educational goal, keeping in pace with a world of discontinuity that we now live in. When considering the use of technology in teaching and learning, a teacher wants to know whether it can make the subject matter more accessible to the learners. In other words, what is in the technology and how it facilitates understanding, retention, retrieval and transfer of knowledge and information in ways non-technological methods cannot. In this paper, I will share two ways that Macromedia Breeze and the IVLE tools can help mediate learning and make the learning process more exciting for students.

Affordances

When the opportunities presented by a piece of technology are taken up to mediate pedagogic content, these opportunities become known as affordances. The term *affordance* has been used to "describe a potential for action, the perceived capacity of an object to enable the assertive will of the actor" (Ryder, 1996). In the context of a virtual learning environment (VLE), affordance is used to describe opportunities provided for learners to alter the state of their subject matter competencies. For teachers engaged in face-to-face teaching, affordances are opportunities available within a pedagogical setting that orchestrates conditions for maximum learning and retention (Kennewell, 2001). The affordances of a physical classroom environment include the opportunities presented by the technology in support of a learning task, the social support for learning provided by the teacher or other learners, and the contextual support provided by the setting in which the activity occurs (Kennewell, Parkinson & Tanner, 2000). In lessons involving the use of ICT and in VLEs, affordances can take the form of computer-intrinsic activities (e.g. entering variables via a Web-form into a computer-simulated furnace to plot graphs)

Table 1: Expository self-instruction and inquiry-based self-instruction contrasted (Keirns, 1999, p. 84)

Expository self-instruction	**Inquiry-based self-instruction**
• content is presented to the learner	• content is provided to the learner
• learner is guided,	• learner is coached and given advice
• learner has opportunities to practise what is learnt	• learner experiences the environment with which meaning is constructed
• the learner is being assessed	• learner monitors own progress

and task-intrinsic activities (e.g. making the link between graph and equation) (Kennewell, *et. al*., 2000).

Self-instruction

Since ICT present affordances that can be taken up in various learning contexts, one way the computer may be able to replace face-to-face teaching is to promote self-instruction. Self-instruction in the broad sense describes "situations in which a learner, with others, or alone, is working without the direct control of a teacher" (Dickinson, 1987, p. 5). In the narrow sense, "it is a deliberate long-term learning project instigated, planned and carried out by the learner alone, without teacher intervention" (Jones, 1998, p. 378).

As the content-to-user, teacher-to-user, user-to-user interactions are pre-planned in self-instructional materials, the self-instruction approach is sometimes preferred over the didactic method especially when the content needs to reach a large audience. Keirns (1999) distinguished between the expository- and inquiry-based self-instruction in Table 1.

Macromedia Breeze and IVLE tools for self-instruction

Macromedia Breeze and IVLE tools allow teachers to plan online activities by using lectures slides and tutorials. Table 2 maps the tenets of expository self-instruction, affordances and technology. Teachers who prefer the didactic method of instruction may use this as a guide to plan online activities.

Table 3 maps the tenets of inquiry-based self-instruction, affordances and technology. Teachers who advocate methods such as collaborative learning, case-based learning or problem-based learning may use this as a guide to plan online activities. However, teachers should provide appropriate rubrics (with explicit behavioural descriptions) and communicate them clearly to the learners to ensure successful teaching and learning.

Table 2: Tenets of expository self-instruction, affordances and technology

Instructional Event	Affordance	Technology
Presenting information	Intentional, through sequencing of content	Macromedia Breeze
Guiding the learner	Assisted performance	Macromedia quizzing with customised feedback messages and/ or polling function
Practicing by the learner	Task-intrinsic activities	Macromedia quizzing functions with immediate feedback and/ or Flash-based simulation inserted
Assessing learner progress	Intentional	IVLE assessment

Table 3: Tenets of inquiry-based self-instruction, affordances and technology

Instructional Event	Affordance	Technology
Providing information	n.a.	Macromedia Breeze
Coaching and advising the learner	Assisted performance	IVLE Discussion forum or IVLE Project with Flash-based simulation or micro-worlds.
Experiencing by the learner	Computer and task-intrinsic activities	Ditto

Final thoughts

Creating VLEs with Macromedia Breeze and IVLE tools does not necessary imply that face-to-face instruction must be replaced completely. In my opinion, this should not be done as teacher-student rapport is important in the learning journey. The teacher plays an instructive role whether learning is self-directed or not. But with technological advancements, it is possible to do more with less. However, the teacher must take time to acquire the necessary skills to configure and manage learning in VLEs. At the same time, teaching staff must adopt an open mind and be willing to suspend their biases before technology-mediated approaches can be introduced successfully.

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The Centre for Development of Teaching and Learning (CDTL) engages in a wide range of activities to promote good teaching and learning at the National University of Singapore, including professional development, teaching and learning support, research on educational issues, and instructional design and development.

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