Our first instalment of CDTL Brief for 2011 is all about the various Teaching Tools our educators use to engage students and stimulate their interest in the subject. Whether commercially procured or developed by the educators themselves, these tools serve to enhance their students’ understanding of abstract concepts and ultimately enrich their learning experience. We are pleased to have colleagues from the medical, science, design and environment as well as engineering faculties share their teaching experiences in this area.

Using Routine Workplace Audits as Education Tools: Teaching Hand Hygiene to Medical Students

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Department of Medicine

As educators, we are increasingly aware of the benefits of practical simulation-based teaching over traditional didactic teaching. In medicine, “real patient learning” has shown how theory, when placed in context, is built upon and better appreciated. Medical students have strongly supported being placed in selected environments where perspective is given to classroom lessons.

Hand hygiene is key in the prevention of the spread of microorganisms responsible for potentially serious health care-associated infections (HAI). However, this is often not adequately recognised by doctors. Despite the well known importance and the ease with which hand hygiene can be undertaken, the average compliance by doctors (even straight after graduation) is poor. In short, as teachers we are failing!

The alcohol glycerol hand rub is effective in this respect and only requires 10 to 20 seconds to administer and can be used while simply walking from patient to patient. It should be undertaken according to the “5 moments of hand hygiene” (see Figure 1), the accepted international standard based on the World Health Organisation’s (WHO) guidelines on hand hygiene in healthcare. A hospital’s performance is assessed by hand hygiene auditors, usually nurses, who unobtrusively observe staff in their daily duties and record compliance.

Figure 1. The 5 moments of hand hygiene.
In the Department of Medicine, we have introduced a novel learning activity where final-year medical students are trained and undertake a hand hygiene audit themselves. We hypothesised that involving students in a ward-based routine audit would provide the opportunity for them to not only observe health workers’ practice in hand washing, but the exercise will also aid in their understanding of how hospital-acquired infection is linked to hand hygiene failure.

These students undertake (among other infectious disease learning modules) a standard hand hygiene auditor training program with a 30-minute tutorial by an infection control nurse trainer using a WHO audit package. The training describes the “5 moments of hand hygiene”, and includes a video demonstrating these moments. To complete the training, each student is assessed by watching three hand hygiene scenarios on video and recording their observations. They are subsequently assigned to 6 or 8 bedded surgical or medical wards for two 30-minute periods to unobtrusively observe hand hygiene opportunities and record their findings (Figure 2).

Student feedback has been overwhelmingly supportive towards our initiative. A survey suggested that while the students did not learn new facts particularly, what they did gain from this exercise was the opportunity of applying their knowledge into this real-world perspective. At least at this early stage, students report that they are more likely to appreciate and comply to these guidelines when they become full-fledged medical practitioners.

Audits are practised in all occupations to review performance and to maintain and improve standards. They are a largely untapped opportunity for teaching. University departments, even those outside of Medicine, could consider where similar learning opportunities exist for their students to obtain such perspectives for what they have learnt in the lecture theatre.

Figure 2. A student observes and records a hand hygiene scenario in the ward.
The Use of Simulation in Paediatric Undergraduate Education

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Department of Paediatrics

The use of simulation in the aviation and nuclear power industries has set the stage for the use of these same tools in medical education. The rationale behind using simulation in teaching clinical medicine seems intuitive, given the need for rational decision-making in stressful situations.

The Department of Paediatrics has incorporated the use of simulation into teaching acute emergencies to fourth year medical students, using high fidelity patient simulators such as SimBaby and Laerdal (see Figure 1). Online lectures are available to the students prior to their encounter with these simulation tools, so as to fill any knowledge gaps that may be present. During the simulation session, students work in groups of 6 to 7 and are presented with a patient scenario, based on real cases, that they may encounter in an emergency department or on the wards when they are on call at night. The objective of this exercise is to allow students to apply what they have learnt in a safe simulated environment that reflects reality. It also provides an opportunity for students to hone their skills in working as a team. They will need to draw on prior knowledge and intervene appropriately. With each intervention, the simulator will respond and the physiological parameters will change accordingly. This should prompt further action from the students if necessary. At the end of the scenario, the facilitator will then debrief the class, utilising this opportunity to reinforce what they did correctly and to rectify mistakes that may have occurred. The debriefing session employs self-reflection and group feedback as core techniques in facilitating learning.

We also performed a pilot study among a group of elective students who were exposed to the same set of simulated clinical scenarios. An anonymous pre- and post-session questionnaire and a feedback form were administered. All responses were rated on a Likert scale of 1 to 5. Informed consent was obtained and participation was voluntary. Based on the pre- and post-session assessment, it was established that the students (n=26) were more confident (1=not confident at all, 5=very confident) with managing acutely ill children after the session (see Table 1).
The mean satisfaction score for all 3 stations in the simulation exercise was ≥4 (1=poor, 5=excellent). All the students who participated in this exercise felt that this training better prepared them for their future job and that it should be made part of the undergraduate curriculum. Simulation-based teaching is associated with increased student confidence in managing acute problems in paediatrics as well as a high degree of student satisfaction. The results provide evidence that simulation should be used in teaching acute paediatric medicine to undergraduate students.

Student feedback from the simulation sessions was largely favourable. Students felt that simulation–based teaching reflected real-life situations in real time. These exercises reinforced their awareness of the sequence of appropriate actions that needed to be taken in such situations and helped them recognise the consequences of their actions in the changes that occurred in the simulator. My favourite quote was from a student who said: “[t]he simulator made words from the book come alive”. In addition, students felt that they were given an opportunity to practice and apply knowledge in a safe environment. The scenarios also required them to think on their feet and respond quickly to situational changes, helping them to prioritise effective management. They were appreciative of the feedback they received from the facilitators that was immediate and non-threatening. They also wanted more sessions, more time for practice and smaller student-teacher ratios.

With technology advancing at lightning speed, the possibilities for the application of simulation in medical education are endless. It is not difficult to envisage a curriculum revolving around virtual patients in various forms, electronic or standardised, in the early phases of a medical student’s education. While it is absolutely true that nothing can replace a real patient, simulation offers an excellent tool in our armamentarium of teaching methodologies and is one that makes intuitive sense. Rather than allow medical education to be dictated by chance encounters between students and patients, a well-rounded, all-encompassing curriculum can be tailored so that all students will be exposed to a more uniform educational experience. From a patient safety point of view, exposure and practice prior to real patient encounters, especially with rare or infrequent but life-threatening conditions, would certainly make a young doctor safer and more prepared for such encounters.

One of the major limitations in the use of simulation is the logistics and cost in terms of equipment and manpower. The key to successfully overcoming such limitations is to choose the appropriate level of simulation that best achieves the objectives or the learning outcomes of the session. This requires careful thought and planning. With time, it is likely that simulation will play a bigger role in medical education as well as in the assessment of clinical competence. The Department of Paediatrics hopes to be at the forefront of this paradigm shift.

<table>
<thead>
<tr>
<th>Skills</th>
<th>Pre-score (mean)</th>
<th>Post score (mean)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bag and mask ventilation</td>
<td>2.32</td>
<td>3.68</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Intubation</td>
<td>1.76</td>
<td>3.32</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Managing arrhythmias</td>
<td>1.64</td>
<td>2.88</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Defibrillation</td>
<td>1.92</td>
<td>2.84</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Managing shock</td>
<td>1.92</td>
<td>2.96</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Identifying a sick child</td>
<td>2.88</td>
<td>3.64</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Identifying cause of shock</td>
<td>2.32</td>
<td>3.24</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Table 1. Results from the pre- and post-session assessments.
The Examination Library Folder (ELF): A Courseware to Manage Examination Questions

Dr. Kang Lifeng
Department of Pharmacy

Introduction

Students’ expectations of the type of exam they may take have greatly influenced the way they study. If students expect an exam which places greater emphasis on the application of knowledge instead of memorising it, then they will learn more deeply (Stanford, 1992). From this point of view, it is crucial to recognise the importance of assessment in the whole process of teaching and learning (Fink, 2003; Searcey, 2006). However, student assessment is a complicated procedure and may lack objectiveness and fairness if there is no proper management of test questions. Many coursewares have been developed to facilitate the assessment process. For example, the test authoring software Questionmark™ provides sophisticated assessment functions for education institutions. These types of courseware are powerful and multifunctional. However, they generally require well-trained personnel to run the programme and are prohibitively expensive for personal users. Alternatively, some universities provide in-house exam courseware to faculty members. For example, the National University of Singapore’s (NUS) e-learning portal, the Integrated Virtual Learning Environment (IVLE) includes a ‘Question Bank’ resource. The Question Bank provides functions such as allowing users to input questions and generate exam papers. However, it has its limitations. First, as it is a web-based application, its users must have internet access, which in turn may cause security concerns such as the potential danger of exam question leakage. Second, it does not provide question descriptors, such as the question’s level difficulty and other properties.

Through this research, the author has developed a courseware for personal users to manage exam questions. The courseware provides a database and several applications to help users manage exam questions. In addition, the courseware would be easy to learn and use.

Developing the Courseware

The courseware, named the Examination Library Folder (ELF), was developed using the Microsoft Visual Foxpro 9.0 programming language. The courseware consists of three parts: a database containing exam questions designed by users, tools to manage these questions and a few types of graphic interface from which users can generate exam papers from the database.

The database contains seven types of questions: multiple-choice questions (MCQ), true-or-false, fill-in-the-blanks, short questions, long questions, matching questions and calculations. To manage these questions, a simple graphical interface was provided to facilitate the adding and editing of questions. To create exam papers from the database, ELF provides two modes (automatic and self-selection) which users can choose from. The automatic mode allows questions to be randomly selected from the database, while the self-selection mode allows users to browse the database and manually select questions from it.

The functions within ELF

To start inputting questions, ELF provides a database to contain all the exam questions. The question and its answer are kept separately. Two properties of each question need to be defined—the chapter where it is from and its
difficulty level (Figure 1). The difficulty of each question has to be defined for users to gauge its ability to differentiate students’ performances. A simple interface was provided to locate, add and edit the questions. The seven types of questions share a similar editing interface, as shown in Figure 1. Folders which contain questions of each difficulty level and type are stored in the database.

Next, exam papers can be generated after the database has been populated with questions and answers. The process of generating exam papers involves selecting a subset of questions from the database (Figure 2). Two modes were provided for users to create the exam papers. In the automatic mode, exam questions are randomly selected from the database based on chosen difficulty levels and types. The whole process takes only a few minutes to complete. The database should contain a sufficient number of questions for the courseware’s automatic mode to generate exam papers. Questions from previous exams may also be reused if the database contained enough number of questions. The reuse of test questions, though controversial, is common practice among lecturers (Gehringer, 2004). Copious test questions will ensure that the same questions will be less frequently selected in the automatic mode. In the self-selection mode, users can select the questions one by one. This mode is similar to the conventional way lecturers set exam questions. It takes a longer time than the automatic mode and the user has full control of the selection process. It is useful when the user is trying to draw students’ attentions towards a certain topic.

Lastly, exam papers are generated by ELF in two text files. One of the files contains both the questions and answers while the other contains only the questions. Both files would be generated and stored in a folder of the programme. A sample file is shown in Figure 3. Each type of questions is numbered and listed in sequence for further editing and formatting.
Bloom’s classification and difficulty levels

While designing ELF and applying it to two courses the author was teaching, the difficulty levels of the questions were set according to Bloom’s classification, i.e., knowledge, comprehension and application (Anderson, Krathwohl et al., 2001). However, the author soon realised this was not correct. There was no correlation between the difficulty levels and Bloom’s levels of learning; they were independent of each other. For example, more than 90% of the students correctly answered the questions at the ‘application level’ in a test. For questions at the ‘knowledge memorisation’ level, less than 50% of the students answered them correctly. Questions which cultivate higher-order thinking (understanding and application) cannot be equated as being more difficult than those of a lower order (knowledge, recall and memorisation). As such, for future developments of the courseware, a new category should be added to ELF, i.e. that the questions reflect Bloom’s classifications in addition to being differentiated by their difficulty levels. It is important to differentiate questions by whether they promote memorisation, comprehension and application for the purpose of teaching and learning.

A student assessment-centred approach

As the centrepiece of the student’s learning process, formative assessment can be used to motivate student learning (Dunn & Mulvenon, 2009). ELF can be a useful tool to implement this approach, as illustrated in Figure 4. Through continuous assessment, in the form of tests and group projects, learning targets can be set and reinforced. ELF can also be applied for both continuous assessment and the final exam to ascertain the consistency of the assessment. The mode of assessment also determines the way of teaching. It should be clarified, however, that ELF is by no means a drill tool to train students to become experts in taking exams. Rather, it is a tool to improve teaching and learning for both lecturers and students through continuous assessment.

In terms of future developments of ELF, one possible improvement to the courseware would be to provide an interface for users to modify the names of chapters in the database. Also, as mentioned earlier, a new category could be added to label the questions according to Bloom’s classification, so that users can differentiate questions of memorisation, comprehension and application. Such classifications would be helpful for users to align their teaching and assessment. Although ELF has only been used in pharmacy courses so far, it is potentially applicable to various courses as it is a general courseware and not specifically designed for pharmacy topics.

Conclusion

ELF provides a useful platform for lecturers to manage exam questions. It can play a vital role in the process of teaching, learning and assessment.

ELF 2011 is free to the NUS teaching community. If you need a copy, please email the author at lkang@nus.edu.sg. More information about ELF can be found at http://staff.science.nus.edu.sg/~phakl/elf.

Acknowledgements

The author would like to thanks Mr Alan Soong from CDTL and Associate Professor Eric Chan from the Department of Pharmacy for stimulating discussions on this research.
Teaching Tools

Personal Experiences in Teaching Chemical Engineering Thermodynamics

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The module CN2121 “Chemical Engineering Thermodynamics” is a core module for undergraduate students taking chemical engineering. The module provides students with a fundamental knowledge of basic thermodynamic concepts and principles, which can be used in the analysis of engineering thermodynamic problems. Thermodynamics is considered a confusing subject and students usually have difficulty understanding its abstract concepts. In this article, I share my personal experiences in teaching this subject. With an objective towards ultimately engaging my students in active learning, what I essentially do is integrate different components into classroom teaching, such as introducing thermodynamic history, using animations, providing practical examples to illustrate how abstract thermodynamic principles are applied to solve real-life problems, and demonstrating computer applications.

When introducing thermodynamic concepts and laws to my students, I show them images of scientists (e.g. James Joule, Sadi Carnot, Heike K. Onnes, van der Waals, Josiah W. Gibbs) who proposed these concepts and developed the laws, and tell them about the related historical background. I think that knowing the scientific history behind the theories can enhance students’ interest and curiosity in the subject. In particular, when I lecture about heat engines and the second law of thermodynamics, I share with students photos of heat engines I took at the Science Museum in London (see Figure 1). By observing the collection of a large number of heat engines from the 19th to the 21st century, students become enthusiastic and eager to learn more about heat engines and the thermodynamic principles involved.

References


In addition, I try to use animations to elucidate abstract concepts. Considered virtual experiments, animations can efficiently capture students’ attention and lead to a better conceptual understanding. For example, when I introduce the different forms of energy, students can easily understand potential and kinetic energies, but are not able to develop a logical understanding of internal energy. Faced with this challenge, I use Figure 2 to elaborate on the dynamic motion of water molecules and the associated internal energy. From this animation, students’ intuitive understanding of the abstract concept of internal energy is substantially enhanced. I also use Figure 2 to explain the concept of phase equilibrium. By visualising the co-existing solid, liquid, and vapour phases as well as the molecular motion, students gain a good understanding of the fact that an equilibrium state is static in the macroscopic scale while being dynamic in the microscopic scale. With the aid of animation, the classroom atmosphere is made more lively and students find it much easier to grasp confusing concepts.

The ultimate goal of learning chemical engineering thermodynamics is to be able to apply thermodynamic principles to solve problems in the chemical industry. For students to better assimilate thermodynamic principles and more importantly, learn how to apply them, I provide thought-provoking examples that are relevant in practice. In one example, shown in Figure 3, students are asked to determine an economically feasible method of storing and transporting natural gas. They are required to estimate the volume of a tank if natural gas is stored as a gas or a liquid, and then to evaluate the pros and cons of each method. From the calculations made based on a commonly used equation of state (e.g. Redlich-Kwong equation), students find out that the volume of the tank is substantially larger if natural gas is stored as a gas; consequently, they can conclude that the more appropriate method of natural gas storage is as a liquid. By working on this example, students understand why natural gas is liquefied for storage and transport. I go on to ask them to discuss why a storage tank is usually designed to be spherical rather than in other shapes. Students’ reactions to such application-oriented examples have been very positive. Such exercises promote critical thinking and students become more engaged in active learning.

In addition, computer technology has been in widespread use for chemical process and product design. As such, I feel that it is necessary to demonstrate to students how computer programming is applied in thermodynamics. One example involves calculating the volumes of saturated vapour and liquid using the Redlich-Kwong equation. If solved manually, lengthy numerical iterations are needed. Instead, I demonstrate how writing a computer programming code rapidly solves the problem. I also upload the code onto the
When it comes to the teaching of practical modules such as PF2302 “Construction Technology”, the teaching objectives we strive for include:

- Equipping students with the latest knowledge in construction technology, maintainability, building diagnosis and repair, as well as enabling them to relate and apply these knowledge in problem solving.
- Enabling students to cultivate the cognitive skills to critically and comparatively analyse:
  - construction detail and methods of achieving appropriate standards of performance relating to weathering, durability, strength, fire resistance, thermal and sound insulation as well as other relevant factors
  - the integration of construction plant and equipment in the erection of buildings, particularly for more complex construction works and under difficult working conditions
  - the economic use of resources.
- Encouraging and promoting creative and innovative thinking through problem solving of real-life problems.

In this article, I will talk about the following teaching aids which were developed to achieve these objectives.

The “Construction Technology” website

In this website (see Figures 1, 2a and 2b), which is meant for teaching and fostering interaction with students, a comprehensive database and information on construction technology has been compiled to include reports, slides and the animations of construction sequences of various elements and components. Students can explore the website at [http://courses.nus.edu.sg/course/bdgchewm/mike-1.html](http://courses.nus.edu.sg/course/bdgchewm/mike-1.html).

Figure 1. Home page of the “Construction Technology” website.
Acquiring a hands-on appreciation for construction equipment

Students taking the module also participated in the following activities to acquire some hands-on experience of construction technology:

i. Construction equipment appreciation.
Students get some hands-on experience operating heavy construction equipment such as excavators, cranes, loaders, back actors etc. This exercise was conducted in collaboration with Caterpillar® International and Tractors Singapore Limited.

ii. Model making workshops. Students are given the opportunity to visualise and appreciate building assembly in 3D (Figure 3). They are given the basic tools and instructions, and are expected to illustrate the assembly process and the integrated operation of various components. These include foundations, waterproofing, basements, structures, connections of components, major equipment such as cranes, as well as temporary structures including scaffolding and system formwork, façades and the roof (Figure 3).
iii. Full-scaled system construction. Students acquire hands-on experience on the assembly and operation of full-scale system formwork, system scaffolding, structural integration, core construction, and so on. Examples of these full-scale construction models are as follows:

a. Formwork. The full-scale system formworks, including climbing and jumping formworks, were set up with constrained resources (see Figures 4a and 4b). They were put together to facilitate students’ understanding of the actual operation of the system formworks and also to enhance their appreciation of the actual working environment and the various constraints one may encounter on-site. Such hands-on experiments are designed to promote and cultivate students’ capacity and innovativeness to come up with creative solutions to overcome these difficulties. The set-up also facilitates any further in-depth research students may embark on for these topics.

b. Curtain walls. Large-scale curtain walls (see Figure 5), including the conventional stick system and the more advanced pressure equalising systems (Figure 6b), were also set up with limited resources. These are the kinds of on-site knowledge that students cannot glean from just reading textbooks or watching videos. Instead, they have the opportunity to see and touch the real assembly, and to ask the ‘real’ questions.
iv. Teaching Laboratory Equipment. These are self-developed and self-fabricated instruments and equipment arising from research by faculty members, which are used for laboratory teaching. Examples of such equipment include:

a. The In-situ Non-destructive Elastic Recovery Tester (INERT). This self-developed, self-fabricated tester is a small, light and portable instrument designed for in-situ measurements of the performance of sealants based on elastic recovery and compressibility. The tester measures the elastic recovery property of sealants based on the principle of compression and relaxation mechanism (see Figure 7a). It also measures compressibility, i.e. resistance to penetration. The data can then be related to the performance based on the data bank already created. The tester is continued on the next page...
also equipped with a magnifying glass for detailed visual examination during testing, especially for adhesion and cohesion monitoring.

b. **Watertightness tester.** This self-developed, self-fabricated watertightness tester allows a chamber to be anchored onto the tested area and is regulated to various pressure levels simulating different levels of wind driven rain. The water seepage can be quantified under the respective pressures (See Figure 7b).

These are just some examples of teaching aids that we have developed for students taking PF2302. It is hoped that exposure to these full-scale construction models will broaden their perspectives on this subject and enrich their learning experience.