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CHALLENGES IN ASSESSMENTS IN A CASE-BASED SCIENCE COURSE

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Abstract

Our experience in a case-based science project at a university in Hong Kong has highlighted the need to go beyond the design and implementation of case-based teaching to have a strong focus on assessment. Traditional assessment is not compatible with the constructivist nature of this new (to Hong Kong) approach to teaching and learning. This paper reports the process of changing the assessment strategies in a Year 1 Surface Science course held in the second term of the 2003–2004 academic year at The Chinese University of Hong Kong. The case-based course and the assessment strategies were evaluated with a range of data from the students and the teachers – surveys, focus groups, the Study Process Questionnaire, performance measures and teacher reflections. While successful in many aspects, the student and teacher workload was high. Modifications are suggested for future work with case-based learning and assessment.

1. Background

A case is a story, often told as a sequence of events in a particular place. Often, there are human actors woven into the case story (Shulman, 1996). A case-based approach emphasizes active construction of knowledge gained from simulated experience. Cases should provide clear contexts in which learners can construct meanings and concepts; Morrison (2001) calls this 'actionable learning'. The context of a case is intended to enable students to put themselves in the role of being an actor in the situation; in this way they are more likely to be engaged in the learning and try to relate what they are learning to previous experiences. Cases may also help learners to develop problem-solving skills and collaborative skills that are recognized as key outcome skills that students will need in their future professional lives (Morrison, 2001).

Shulman (1996) provided a long list of potential benefits for case-based teaching and learning. For example, cases may: aid in teaching principles or concepts of a theoretical nature by showing the occasions when the theories are applicable; illustrate the precedents for practice, in abstract and context-dependent issues such as morals or ethics; train students in analytic strategies and skills; and increase students' motivation for learning. In addition, Harrington et al. (1996) remarked that teachers would also benefit from taking a case-based approach to their teaching as they have a chance to reflect upon the learning process when they write and introduce the cases in their classes.

Much attention has been paid to the pedagogy, while comparatively less interest has been shown to the assessment of case-based courses. This is problematic as assessment is often the key to the overall success of any teaching innovation, as

assessment has a marked effect on how teachers teach and students learn. This is often termed 'the backwash effect', e.g. Elton, 2002. For example, a poorly designed or implemented assessment has the danger of wrongly focusing students' attention onto surface learning skills such as rote memorization, and so diluting or even ruining the whole purpose of the case-based approach.

Traditional forms of assessment are not compatible with the overall constructivist nature of the case-based approach of learning and teaching. As Figure 1 summarizes, the case-based approach has characteristics that include: students taking a more prominent role in the classroom, teachers emphasizing both the learning process and the product, and teachers paying attention to both students' individual and in-group performances. However, traditional assessment has teachers playing the key role, with the predominant mode being the grading of students' products in testing situations where students usually work alone. Thus, the learning process is not included in the assessment scheme and this de-emphasizes the process elements of such attributes as problem-solving, team work and communicative competence.

Employing traditional assessment in classes where the case-based approach is adopted is counter-productive. Some students who sense this limitation of traditional assessment will be de-motivated to contribute to group activities.

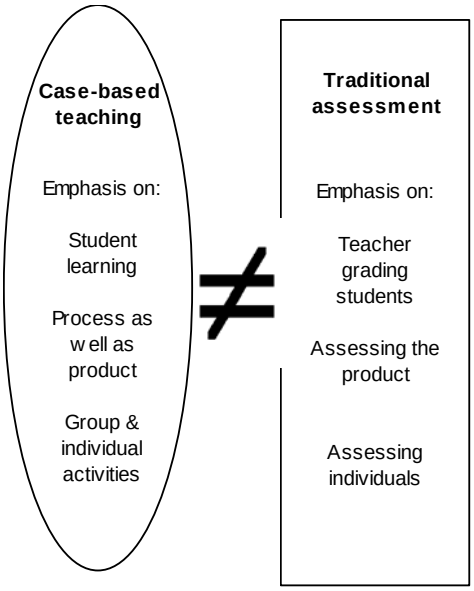


Figure 1: Mismatches between traditional assessment and the case-based approach

An ideal assessment design for case-based courses should match the constructivist nature of the case-based approach. As illustrated in Figure 2, the assessment process should allow students to play a more prominent role in the design of assessments and encompass a wider range of student performances. With case-based assessment, emphasis is also put on monitoring students' process in completing the case-based activities, rather than on the products alone. The 'new' assessment requires students to demonstrate competence across a range of learning processes and learning skills, such as information searching, working in groups, and making presentations, which are often not required in a traditional course.

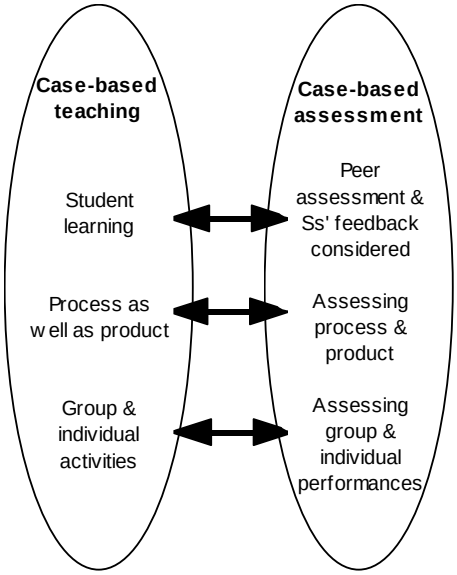


Figure 2: Making assessment and teaching match in the case-based approach

The present paper describes an endeavour to implement these changes in a case-based course, included in a project designed to introduce the case-based approach to the teaching of university science. The focus of the paper is on the design of this case-based assessment, rather than on the design of the cases used in the course. The case-based course and the assessment strategies were evaluated with data from the both students and the teacher.

2. The course and the assessment strategies

This study is part of a three-year project that began in the year 2002 aimed at implementing a case-based approach to teaching and learning in a selected set of science courses in Hong Kong universities. As using cases to teach science subjects is a relatively new idea in Hong Kong, the project began by writing cases suitable for the context using industrial research data gathered in the Advanced Surface and Materials Analysis Centre in the Department of Physics at The Chinese University of Hong Kong (CUHK). Then, a number of trial runs were carried out in various undergraduate and postgraduate courses in the Material Science stream of the Department (six case-based courses have been completed thus far). Earlier work in the project is reported in McNaught et al. (2005).

As the project progressed, it became apparent that we needed to focus as much attention to the design of assessment as we did to the writing of cases. This paper reports one of the project's attempts in designing and implementing case-based assessment in a case-based Year 1 Surface Science course held in the second term of the 2003–2004 academic year at CUHK. There were 22 students in the course which was separated into two main phases. The first phase used a group-based peer teaching strategy in which the students were required to go through some cooperative learning activities, centred around four important topics of the subject. The students self-studied material, discussed the concepts in their own small group and then taught their classmates. They were provided with readings and a detailed study guide in order to scaffold (e.g. Jonassen, 1999) their learning. This first phase was seen as formative, and the presentations were set as importance 'practice'.

The second phase of the course involved the introduction of a Materials Science case. Students discussed in groups, searched for information, made decisions concerning the problems posted in the case, and lastly presented their ideas to the whole class. There were thus two rounds of class presentations. However, the assessment for the course was focused on the second phase where the case was analysed and presented.

Care was taken to implement the assessments for this Year 1 course in ways that matched the overall case-based approach such that the assessments: shifted from being solely teacher-centred to actively involving students' contributions; had a mechanism to distinguish not only group but also individual performances; and were able to monitor students' capabilities in a range of learning processes and skills.

In order to achieve these aims, the following strategies were taken. To encourage student contribution to the assessment, all assessment criteria were laid down at the beginning of the course and a briefing session was introduced to clearly explain the format of the course and the relatively complicated assessment model. Students were asked to comment on the assessments. Their feedback led to refinement of the format and timetabling of the assessments. All cases were coupled with very clear statements of requirements followed by a detailed marking scheme as a result of the students' opinions. Students' contribution was also seen in the peer assessment activities introduced to the course: group members graded each other, based on their participation and contribution within the group.

To enact a mechanism which distinguished not only group but also individual performances, the teacher of the course introduced consultation sessions in which he monitored individual performances. There was a course-end examination testing knowledge that the individual students learnt both from doing their own projects and from their peers through their presentations. There was also peer feedback of contributions from individual members in a group. The group performance was monitored by group presentations and reports.

To monitor students' capabilities in a range of learning processes and skills, the grades were not only allocated to the products, but were also allocated to the intervening processes. The teacher monitored the abilities of the students in understanding the issues in the case, generating a hypothesis on their own, and searching for information in the early consultation sessions in which he met each of the groups in turn. He then monitored the groups' group-working skills, problem-solving abilities and the knowledge they learnt in the classroom activities when he gave time to the students to have group discussions in class. Lastly, analytic skills and presentation skills were demonstrated on

the occasion when the students presented their solutions to the cases at the end of the course.

There was a careful record kept of each interaction between the teacher and students and detailed mark sheets were maintained.

The course-end examination was also changed to cope with the case-based nature of the course. The teacher had deliberately included more demanding questions that called for understanding of a situation, application of theories and concepts, and solving problems.

The assessment mechanism is captured in Table 1, which shows the various assessment methods (teacher-grading or peer-grading) employed in the course to monitor both the group and the individual performances.

	Beginning	*Middle*	*End*
Typical processes/ skills	Understanding of the issue. Generating hypothesis. Information seeking	Group-working. Problem-solving. Knowledge acquired	Presentation. Clarity of thoughts. Practicality of solutions
Group performance (Teacher-assessor)	Early consultation sessions*	Classroom observations* (*total 10%)	Presentation marks (30%)
(Peer-assessor)	--	--	--
Individual performance (Teacher-assessor)	Q&A in consultation*	--	Exam marks (50%)
(Peer-assessor)	--	Comments on others' contribution (5%)	--

Table 1: Assessments designed for the case-based course

Multiple sources of data were used to evaluate the course, as illustrated in Figure 3 (after the model of Lam & McNaught, 2004). The data covers feedback of both the teacher and students, as well as the performance of the students.

The teacher data included collection of the teacher's reflection and discussions with other research members during observations of the class in action. The student data were rich. The revised two-factor Study Process Questionnaire (SPQ) was used (Biggs et al., 2001); in this version, the achieving scale of the first version (Biggs 1987) is incorporated into the deep scale. The SPQ is a 20-item questionnaire which provides a measure of students' approaches to learning on two scales (surface and deep). The SPQ was administered twice: once at the beginning of the course and again at the end, to monitor changes in learning motivation and strategies. Written surveys were also administered once in mid-term (response rate 85%) and once at the end of the course (response rate 95%) to collect students' opinions on the teaching and assessment approach. The mid-term survey had 15 Likert-scale items and three open-ended questions and was administered at the end-of March, 2004, in class. The main focus of this survey was the first phase of the course about self-studying and peer-teaching. The course-end survey consisted of nine Likert-scale items and four open-ended questions. It was administered at the end of April, 2004, and focused on both the case-handling experience of the second phase and students' overall comments on the whole approach used in the course. A one-hour focus-group meeting was held with 13 randomly-selected students in the course to discuss their feelings towards the course. Lastly students' performance data were also collected. Marks were obtained for: students' presentations, case reports and final examination results.

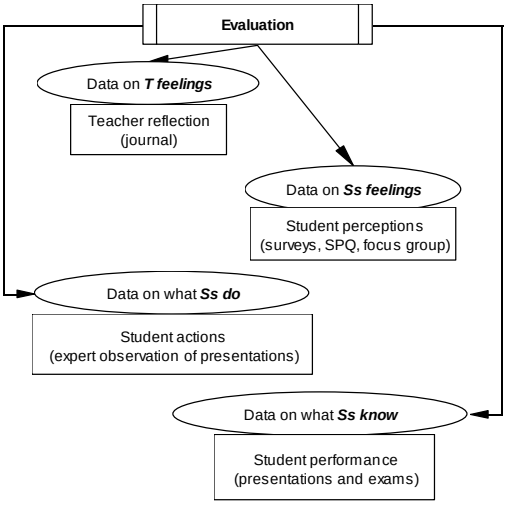


Figure 3: Evaluation data types

The evaluation looked at the appropriateness of the new assessment strategies, as well as the performance of the case-based approach in supporting students to attain the desired learning outcomes.

3. Findings and discussion

3.1. On the design of the assessment

Overall, the design of the assessments seemed to have strengthened the students' motivation to learn beyond the basics of the subject area. The teacher reflected that he noticed great enthusiasm on the students' part when they did self-study and also when they prepared for the case; this was considered to be the result of the fact that the course emphasized the monitoring of the different stages of the students' learning process.

The shortcomings recorded, however, included that the teacher had a much heavier workload, and that the students were unsure about the limits of their knowledge exploration before they could claim that they had fulfilled the course's expectation.

Comments on the individual assessment strategies collected from the surveys and the focus group interview were: concerning the *early consultation sessions*, the teacher thought that he was successful in recognizing the self-study, group-working and problem-solving difficulties of the students before it was too late but the practice "doubled or even tripled the workload". The students felt that they actually progressed a great deal in both knowledge and learning skills through the consultation sessions and they felt "a learning curve is drawn".

Concerning *the classroom observations* which were designed to rate students' abilities to participate in group discussion and give effective presentations, the strategy was considered to be of high value. The physics teachers and the educational observers could easily identify evidence of good group-working and presentation skills, and they also found they gave quite high ratings to these skills.

The *presentation and reporting assessments* were considered fair by the students but they were less certain about how much they actually learnt from the presentations of other groups. Students thought it fair that there were strategies to track individual performances rather than assigning the same marks to all members in the same group. Individual performances were distinguished by the teacher's paying attention to individual performances in consultation sessions and in presentations, and students giving peer comments at the end of the course to rate group members' contributions. One student remarked "I can learn from others through peer-commenting". The teacher, however, remarked that the students were still not very comfortable in criticizing each other and they "gave each other very similar marks". However, when considering how much students felt they learnt from the presentation sessions, there was only some agreement with the statement in the mid-term survey that "listening to the other groups' presentations is an effective way of learning" (students; mean score = 2.84; 5 = strongly agree, 1 = strongly disagree on all questionnaire items).

Lastly, concerning the *course-end examination*, the teacher was pleased that he had put effort into diversifying the nature of the questions in the paper so that many of the questions reflected the thinking skills the students had been trained in through the case-based activities in the course. As a result, questions not only required students to simply remember or understand concepts, but also to apply them, use them to analyse new situations and data, synthesize a number of ideas in order to solve problems, and evaluate strategies (Bloom's taxonomy: Bloom, 1956; revised Bloom's taxonomy: Krathwohl, 2002). Examples of the examination questions are in Table 2. Students were told that the case-based learning activities and the examination would be closely related and, naturally, this contributed to an increase in students' motivation in going through the various non-traditional case-based activities in the course.

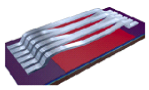
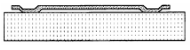
Level	*Example questions*
Application/ analysis	Describe the procedures of making the following 3-D structure:  Example Poly-Si beam process sequence   Si Phosphosilicate glass Polysilicon PSG= Phosphorus Silicate Glass (a CVD oxide)
Synthesis/ evaluation	A solder interface is being examined by Auger electron spectroscopy (AES) and X-ray dispersive spectroscopy (EDX). Which technique can provide information whether there is an intermetallic formed? Why?

Table 2: Sample higher level examination questions

3.2 On the overall case-based approach

The data collected showed somewhat encouraging results concerning the overall case-based approach. It was found that many students (but no means all of them) were satisfied with the skills acquired from the activities. For example, 37% and 53% of the course-end survey respondents agreed that the activities have improved their "problem-solving skills" (mean score = 3.21) and "presentation skills" (mean score = 3.53), respectively. Also, it was stated in the focus group meeting that this course related more to real-life situations and this was good for students. Furthermore, during the presentation sessions, several observers joined the class and found that most of the students were able to work well in groups (indicative of enhanced team-working skills) and they were able to speak in public (presentation skills).

Concerning the potential for learning brought by the new method, students were guardedly positive. Students generally agreed to the statements in the course-end survey "I learned a lot more about the theories and concepts of materials science by going through the cases" (mean score = 3.62) and "I learned much about how to apply materials science theories and concepts to solve real problems by going through the cases (mean score = 3.43). Also, more than 80% of the survey respondents claimed that they needed to have significant periods of self-studying in order to work effectively on the cases (mean = 4.00). This indicates that students were motivated enough to be willing to spend time to learn. Furthermore, more than 60% of the respondents agreed that "I learned more by going through the cases than I could have learned if the course had been conducted in a traditional format" (mean score = 3.57).

In the focus group meeting, most of the students expressed the belief that they got a deeper understanding of their presented topic because of the required peer teaching; they needed to know more in order to present their points and teach their peers. Note that this is in contrast to their limited enthusiasm for learning from other groups. Overall, students felt they learnt from self-study, group discussion and actual presentation about their given topic or case but were less sure that they learnt from others. This does support our belief that learning requires active student engagement and 'second hand' learning is not as effective.

At the end of the focus group meeting, students were given three options on improving the course and they were asked to vote. They were asked to vote concerning the types of course design they would like to see if they were to take this course again. The three options the students considered were: 1) keep the course similar, but increase the credit of the course; 2) keep the self-study and case-related parts, but include some lectures at the beginning of the course to talk about basics, and also increase course credit; and 3) revert to lecture-based and traditional design. Most students voted for the core elements of the case-based teaching to retain. Details of the vote are in Table 3:

Model	*Number of Students*
1. Similar design + increased credit	2
2. Lecturing for basics + self-study + case + increased credit	9
3. Traditional	2

Table 3: Results of the votes to continue the case-based approach in the future

A positive effect on learning outcome was also evidenced by an analysis of students' learning outcomes on the final examination. The analysis was conducted based on Bloom's Taxonomy: the questions in the final examination were grouped into three different categories, according to their levels of cognitive reasoning required. The three categories are: 1) knowing/ comprehending, 2) applying/ analysing, and 3) synthesizing/ evaluating. The classification of the questions was checked by fellow physicists and a science educator.

As shown in Figure 4, students performed quite well in the first and second category, with an average percentage score of 79.7 and 81.0 respectively (where 100 represents full marks for that category of question). They even achieved higher scores in the second category than in the first category questions. This fact surprised the authors and the teacher as first year students were previously recognized as not particularly strong in tackling problems that require application of theories and analysis of situations and data. The data seems to suggest that the cases might have some positive influence on the students' ability to tackle more difficult questions. The fact that students achieved 67.5 percent of the possible marks on the

very complex questions in the section is also pleasing.

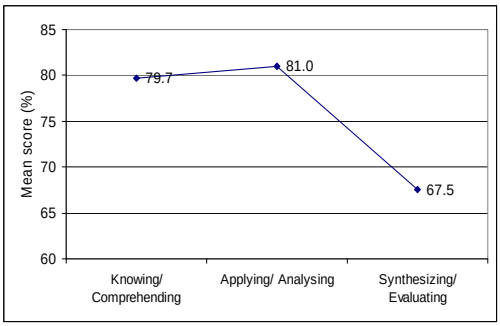


Figure 4: Students' performance in examination questions that require different levels of understanding

Despite the promising results portrayed above, evaluation also showed areas of concerns and possibilities for improvement. On the whole, students found the workload too harsh for this one-credit course. [Students at first year typically take around 15 credit points each semester.] Students were required to work on the task without much prior knowledge on the topic. From the mid-term evaluation survey data, more than 60% of the respondents disagreed that "the workload of the Cooperative Learning Activities is manageable" (mean score = 2.21). In the course-end survey, more than 30% of the respondents "strongly disagreed" to the statement "I found completing the cases enjoyable" (mean score = 3.29).

The SPQ data indicate the pressure students were under as well. The results are in Table 4. The students' deep approach scores increased, though not significantly. Their surface approach scores, however, increased more and this increase was statistically significant. Given the other data we have about student's engagement in the course, our interpretation is that the workload pressure caused the students to feel they were attempting to 'cut corners' in the work they did.

Approach to learning		N	Mean	Std. Deviation	t-test result*
DA	pre	22	29.77	4.72	N.S.
	post	21	30.67	4.90	
SA	pre	22	26.50	4.90	S.
	post	21	30.95	5.64	

* It is best to use paired-t tests in this situation. However, we did not have paired data and the less powerful individual t-test was used. N.S. – not significant.
S. – significant difference

Table 4: SPQ data

4. Conclusion

Taking the whole course into account, although the data do indicate a number of challenges, we still have a picture that shows the potential of case-based learning and we certainly had some significant achievements.

In particular, the attempt to match the assessment strategies with the constructivist characteristics of the case-based approach seemed to be a success: 1) students were able to contribute to the assessment (giving comments on assessment strategies and commenting on their peers' performance); 2) the assessment that considered both students' learning process and products ran smoothly and seemed to have promoted students' interest and motivation in the activities; and 3) the attention paid to distinguish individual performances from the group performances was also worthwhile and well-appreciated by the students and teacher.

There was more learning *within* groups than *between* groups in both phases of the course. While this does not surprise us, it does create challenges for designing learning tasks so that students not only learn some material in depth but also gain an adequate coverage of course topics. The balance between a totally case-based course and one which is a hybrid of self-learning, case-based tasks and conventional lectures seems to be an appropriate design model, and one we will adopt for our future courses.

The major problem, though, in this course was the workload on both the students' part in completing the many demanding activities, and in the teacher's part in paying attention to the numerous aspects concerning the learning process and products in the various stages of the course. It is clear that case-based courses take time and this factor needs to be reflected in the credit allowance for students and the teaching load allocation for teachers.

In summary, the study has collected ideas for future adjustments in design. It is clear that a hybrid lecture-with-case-based model seems to be more suitable to the Hong Kong context. It also seems that even more guidance should be given to students to help them understand the expected learning outcomes of all the individual activities of the course, so as to help them self-monitor their progress.

Building a culture of active, student-centred science classes in Hong Kong universities will take time. Case-based assessment strategies will be integral to that endeavour.

Acknowledgement

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