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E-assessment and tailored feedback - are they contributing to the effectiveness of chemical engineering education?.

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E-assessment and tailored feedback – are they contributing to the effectiveness of chemical engineering education?

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***Abstract*—E-assessment and tailored feedback are explored in this contribution as a means of encouraging deeper learning and increasing the effectiveness of chemical engineering education within the context of increasing larger cohort sizes in a UK Russel group institution. The results presented here indicate the benefits of both approaches to student learning, detail the implementation aspects and highlight the challenges that remain to be addressed. In addition, the results of a recent iTeach project on evaluating the effectiveness of teaching are discussed from the view point of the methods of assessment currently used. This contribution should therefore be valuable to any (engineering) higher education practitioner wishing to introduce (or extend the use of) either e-assessment or self-reflective tailored feedback in their own practice.**

Keywords—e-assessment; effectiveness; active learning; peer assisted learning; chemical engineering education

I. INTRODUCTION

Assessment and feedback represent an integral part of the learning, particularly in constructively aligned programmes typical of chemical engineering education worldwide [1]. In a recent research the traditional methods of delivery and assessments (lectures and exams) were identified as still being predominant in chemical engineering courses in most countries [2]. The research explored the views of academics, industrialists, students and graduates, mainly around Europe, on various aspects of teaching chemical engineering core knowledge and employability competencies. It also highlighted the significance of varied teaching approaches in order to increase the effectiveness of the learning. It is widely recognized that the demographic changes in student population, their technological prowess and learning expectations as well as technology progress led to increasing application of blended learning and assessment methods. Active learning methods have been explored in a range of articles, although frequently very little objective evidence is provided to robustly evaluate their effectiveness. As Prince [3] highlights, this is due to a number of issues relating both to the definition of the object of the studies reported and also to challenges in terms of measuring "what works". However, having critically reviewed the literature on this topic available at the time, Prince also comes to the conclusion, that a variety of methods, including active learning, should be applied in teaching. Extensive pedagogical literature also points to the need for a diversity of assessment tasks in order to induce deeper learning in students (e.g. [4]).

Within the UK chemical engineering context, the recent sustained increase in student numbers also led to additional challenges both in terms of teaching and assessment in larger cohorts. Various means are being implemented by the chemical engineering education providers to address this challenge, including the increasing implementation of e-assessment and e-grading, partly in order to provide faster feedback to an increasing number of students.

Effective feedback in higher education has been a subject of extensive research [5]. In particular, the role of self-reflection in developing more autonomous learners has been discussed in a range of subject areas [6]. In engineering, where numerical assessment is frequently used, the reflection is often limited to learning logs. We investigated student engagement in the assessment and feedback process by introducing reflective statements that students are asked to complete before submitting summative assessment. These provided qualitative and quantitative data on the effectiveness of self-reflection. The key research question is whether self-reflection on all summative course assessment in a highly numerate subject area (chemical engineering) improves learning autonomy and student satisfaction with resulting feedback.

This paper explores the contribution of e-assessment and tailored feedback on in-course assessment on the effectiveness of teaching chemical engineering. E-tutorials/tests have been implemented in a range of core subjects in Years 1 and 3 of the course and their impact on student learning is assessed. A range of methods has been also used to collect both quantitative and qualitative data and gather evidence of student reasoning and satisfaction with tailored feedback. Students from Years 2 to 4 took part in this evaluation and a number of academics using the system also provided qualitative feedback.

II. METHODS

A. E-assessment

A set of e-tutorial tests were developed both within the mass and energy balance course in Year 1 and the solids handling and

reactor engineering courses in Year 3 of Newcastle University Chemical Engineering Degrees. The tests were implemented in the VLE environment used across the University (Blackboard) and implemented over the period of 6 years. The questions were set up to accept calculations with a specified level of accuracy and provide automatic feedback indicating potential errors in case of an incorrect answer. In certain tests, multiple attempts were allowed, in other cases the first attempt was graded. The grades were used purely formatively from the students' point of view. From the instructor's point of view, grades were used to assign students into tutorial groups on the basis of the overall score so that students with similar problems were grouped into the same session. This was possible due to the design of the tests and of the marking scheme.

B. *Tailored feedback*

At the point of submission of any in-course assessment work, the students were asked to complete a cover sheet, responding to three questions:

- The strongest aspects of your assignment
- Areas that may require further improvements
- Specific feedback on two clearly identified points requested

In the first year of operation of this system, students were strongly encouraged to complete the cover sheet and the academics were requested to respond to the points raised by the students. In a second year of operation (based on feedback reported in the Results section) the completion of the cover sheet was more rigorously enforced at the point of the submission of the work. The response from the academics was also checked by the Degree Programme Director to ensure wider compliance.

In the first year of operation of the tailored feedback cover sheet, the views of the students on this approach were sought in a focus group. Volunteer students from Year 3 were invited to attend and use the diamond ranking approach [7] to identify the most significant benefits and challenges of this approach. The specific questions asked from the students were:

- What are the most important characteristics of feedback that help me improve my work?
- Thinking about the current feedback form, what are the characteristics of the current course feedback system which help me learn best?

In total 16 students from Year 3 attended, working in groups of 4 and producing 4 diamond ranking outputs. The focus group session was followed by a semi-structured interview session with 12 students, using the outcome of the diamond ranking to provide starting point for discussions. Students engaged actively in all three of these methods and provided valuable insight into the impact of self-reflection. In addition, the author analysed over 300 marked assignments from Stages 1-3 to assess the quality of self-reflection and that of the resulting feedback and the final mark.

C. *Effectiveness of teaching and assessment*

As part of the iTeach project (www.iteach-chemeng.eu) a set of questionnaires were sent out to academics, industrialists, graduates and students across Europe and the world (see [2] for more details). In a wide range of questions on the importance of specific chemical engineering learning outcomes, current methods of teaching and assessing the effectiveness of these, free text responses of academics on current methods of assessment are considered in this paper. Thematic analysis [8] was employed on the free text responses using NVivo 10. Respondents' comments were initially sorted into broad analytical categories corresponding to the survey questions. In the subsequent step, every statement in the broad categories was analysed for content and placed under an appropriate heading or thematic 'node' along with any other responses which were sufficiently similar [9]. This process generated a collection of sub-themes for each analytical category.

D. *Evaluation*

In each year and student cohort, a questionnaire was administered to the students electronically. Initially this was carried out in a scheduled contact time using a Student Response System (Turning Point). In this academic year an electronic survey link was emailed to all students that were part of the research and regular reminders were sent to encourage the completion of the questionnaires.

III. RESULTS

The results are divided into three sections, reporting the qualitative results on the effectiveness of teaching and assessment first (see section II.C) before summarizing the quantitative findings on the use of e-tutorials/tests and tailored feedback (sections II.A and B).

A. *Effectiveness of teaching and assessment*

Ninety (90) responses to the survey were received from academics, representing at least 67 higher education institutions (based on the affiliations stated by respondents providing contact details). The demographic data on the respondents' position and region show that 71% of responders were senior (above but not including the grade of lecturer or equivalent, thus including all grades or equivalent of Senior lecturers, Readers, Assistant/Associate Professor, Senior Teaching Fellow and above) and 29% junior academics, and 96.9% of the responses were received from European countries. As expected, senior academics represent the predominant proportion of respondents as they were targeted as a priority, given their experience in programme structures.

Nvivo thematic analysis clearly indicated the predominance of examinations and in-course assessment as a means of evaluating the effectiveness of teaching in all identified areas of learning outcomes of chemical engineering curriculum. A number of the respondents highlighted the challenges in objectively measuring the level of achievement by the students that can be evidenced for the accreditation and quality assurance purposes. On the other hand, it should be acknowledged, that in their professional practice, chemical engineers rarely experience situations of knowledge testing akin to the examinations. Arguably, design and project reports and various assessment methods not relying on tests, are more aligned with the realities of professional practice. However, these methods also introduce challenges in reliably evaluating individual student contribution

(in the case of group projects) or robust criteria of assessing competencies, rather than factual knowledge [10].

B. E-assessment

Figure 1 indicates the output of one of the e-tutorials/tests set up in Year 3 solids handling course. As indicated in Figure 1, the Grade Centre system within the Blackboard VLE environment clearly records information on the last attempted date and the scores achieved by each student in each task (note that student names are blacked out to protect their identity). The system also indicates where a student started the assessment, but has not submitted their final solutions (a notepad sign) or where the student has not even started the task ('--'). This level of detail enables the instructor to monitor the compliance, remind the students of the set deadlines, and finally, to arrange the groupings of students for each physical tutorial group session to ensure similar ability students (with similar issues) are present in each session, maximizing the benefit for the students by concentrating on the common misconceptions and mistakes.

This feature was highlighted in the informal feedback students provided following the course as particularly important as they frequently ended up in tutorial groups of highly mixed abilities where some students were bored by the slow pace of addressing issues, whilst other students were overwhelmed or not satisfied as insufficient time was dedicated to addressing their issues. The closer match of abilities within the tutorial groups also promoted a better use of peer assisted learning, where students within the groups experienced a higher level of freedom to discuss their issues and were capable to support each other's learning.

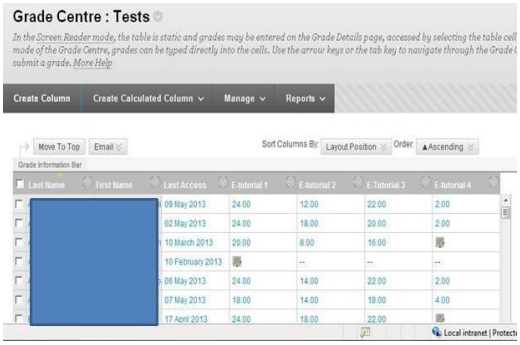

Figure 1: Example of output of e-test in Blackboard

In all student cohorts over the years of using the e-tutorials/tests, the students consistently rated their usefulness very highly. For example, see Figure 2 for Year 1 analysis (n=103) with the mass and energy balances course.

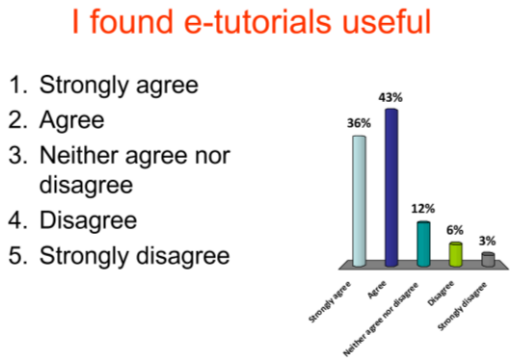

Figure 2: Year 1 responses (n=103) to questions on perceived usefulness of the usefulness of e-tutorials.

During the Student/Staff committee discussions that provide a formal opportunity for students to comment on the effectiveness of the delivery of the course and any issues arising, the e-tutorials/tests were highlighted as particularly positive and students expressed a wish for these to be implemented more widely within the course.

When the reasons for such positive perceptions were explored in more depth, students generally indicated that using e-tutorial/test format (as opposed to traditional tutorial or short test formats) forced them to practice the problem solving (see Figure 3).

Informal feedback from Year 3 students indicated that when set the task by traditional means, they were less inclined to complete the task, despite the fact that they understood the implications in terms of revision and preparation for the exams. Whilst it could be argued that setting the assessment as summative may have achieved similar (or better) rates of compliance, we believe that the benefits of formative assessment outweigh such considerations. It also aligns more closely with the situations arising within the professional practice conduct and with the 'technology-savviness' of the students discussed in more detail in section I.

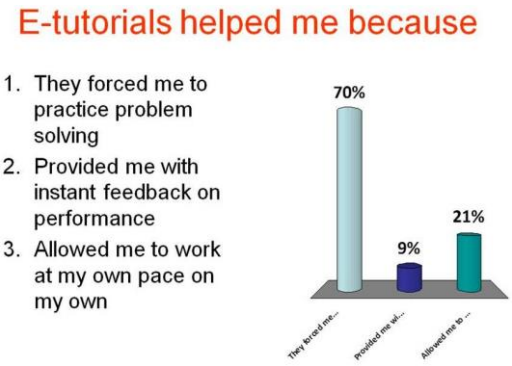

Figure 3: Year 1 responses (n=103) to questions on perceived reasons for the usefulness of e-tutorials.

C. Tailored feedback

As described in section II, the tailored feedback cover sheet requiring self-reflection from the students before submitting any course work was implemented over a number of years and the

analysis of the results that follows is based on various aspects of the evaluation over the years of application.

The diamond ranking approach was used in the first year of implementation to gain an insight in the perceptions of the students in terms of benefits and challenges associated with the implementation of such tailored feedback. As an example, Figure 4 graphically illustrates the output of such a diamond ranking exercise completed by one of the groups. In the exercise, students were given a number of statements (orange rectangles in Figure 4) pertaining to the use of the tailored feedback and they were asked to order them into a diamond shape, with the top statement being most important, the second tier two statements being equally important as each other, but less so that the top statement and the bottom statement being least important. The students in the group had to agree on the positioning of the statements and record their reasoning for such position by using text surrounding the resulting diamond ranking.

The majority of the groups highlighted the opportunity to ask for (and receive) specific feedback on areas of the assignment they had most concerns about as the most important benefits of the tailored feedback. These may not have been necessarily the points that the marker would have picked up, but allayed the internal fears and concerns of the students, hence increasing their satisfaction with the feedback and their perception of the usefulness of such feedback.

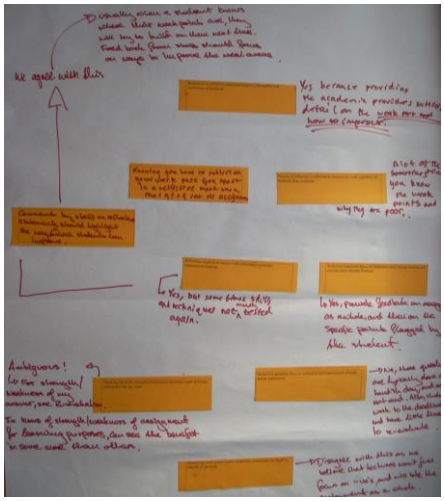

Figure 4: Diamond ranking output on the benefits and challenges of tailored feedback sheet.

Figure 5 illustrates graphically the most significant issues encountered in the implementation of the tailored feedback process as highlighted also in the focus group discussions. These concerns related in particular to three specific areas:

- students are still not using self-reflection widely – approximately ¼ of students admitting to never filling in this section (Figure 5 a and b)
- a number of academics do not respond to the issues raised by the students. This is supported by evidence from the questionnaires, in particular for Year 3 (Figure 5, d), where the proportion of students not receiving tailored feedback to their issues is nearly 1/3.

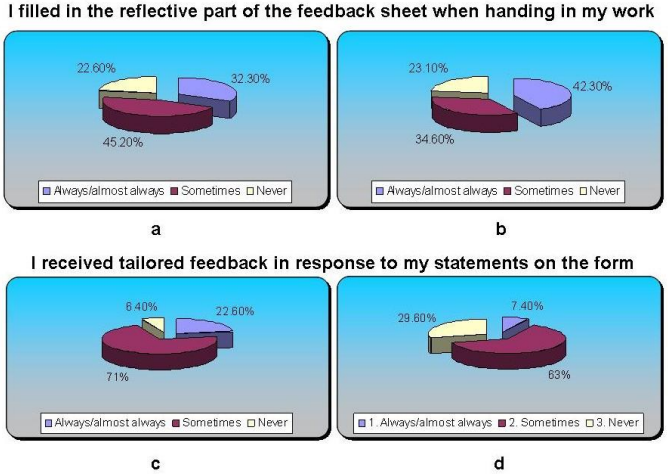

Figure 5: Student responses to questionnaires on the use of tailored feedback cover sheet: (a) and (c) – Year 1, n = 32; (b) and (d) – Year 3, n = 33.

Results of the focus group discussions and the qualitative analysis of the feedback provided to the students confirm that when self-reflection is used, the feedback is more valuable to students. Those students routinely using self-reflection tend to be more satisfied with feedback and also receive higher marks. However, this is not surprising as more conscientious, hard working students tend to fill in the self-reflection section more frequently and also pay more attention to the feedback provided. Discussions with academics confirms that those providing tailored feedback prefer this method as they feel they are providing more value to the student and also understand more clearly the concerns of individual students.

Another issue raised by the students was the fact that even if tailored feedback is provided, the character of individual assessment is so diverse, that generic learning from feedback on individual assessment in each module is difficult to identify.

In subsequent years of operation, the compliance was more strictly enforced both on the student and staff side and the results improved (data not shown) in terms of compliance and satisfaction. However, following the institutional move to electronic submission of work the use of the tailored feedback sheet was initially scaled down until an appropriate mechanism of implementing it within the new system was developed. The latest feedback from students in Year 4 indicates that they still highly value the response to their specific concerns.

IV. Conclusions

This contribution reported the results of the survey on the methods of evaluating the effectiveness of learning through assessment tools, as carried out by the iTeach project (www.iteach-chemeng.eu) and indicated a predominance of exams and test still being used for this purpose. At the same time it indicated the increasing use of alternative means of assessment.

E-assessment in particular was then explored as a means of encouraging deeper learning and providing the students with the opportunity to undertake the formative assessment within the

VLE system and at a time of their choosing (within set deadlines). Additional benefits in assigning students into more similar groups in terms of abilities for face-to-face tutorials were also outlined.

Finally, the implementation of a tailored self-reflective feedback cover sheet was described and the challenges in enforcing compliance as well as the benefits of using such a feedback sheet were discussed in detail.

ACKNOWLEDGMENT

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