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Enabling student to proactively evaluate, test and adapt the effectiveness of their learning through interactive online formative assessment

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ABSTRACT

Whether we like it or not, when it comes to learning, most students are motivated by the desire to demonstrate success in the summative assessment component of the course, rather than implicitly develop their depth of knowledge, understanding and application of subject matter at hand. Viewing learning from this perspective, it is therefore vitally important to select and embed the 'right' assessment strategy as this will affect how and what students decide to learn, as well as how much time and effort they prioritise to different tasks and/or learning resources.

In an attempt to break this cycle of assessment-driven learning, and in line with Vygotsky's work on learning progression in which intervention allows an individual to develop further than if left on their own, a formative learning framework was developed to encourage students to take a more reflective and constructivist approach to their learning.

The framework (originally funded by Centre for Open Learning in Maths, Science, Computing and Technology CETL at The Open University), was designed to enhance student awareness, understanding and recognition of competency levels from a learning outcomes approach, and to allow them to test their ongoing academic progress at predetermined and self-selected points throughout the year. By working through each of the formative assessments, it was envisaged that students would become more self-directed and confident in their learning skills and abilities, and that this in turn would aid retention.

This paper presents data collected over two years on how students have engaged with this learning tool, the impact it has had on their perceived learning abilities and progression, the variances between expected and actual use. Some preliminary thoughts are then presented on how formative assessment can be used as a successful method of helping students learn how they learn, and how to do this more effectively.

KEYWORDS

Formative assessment; online learning; scaffolded learning; constructivist learning support

INTRODUCTION

It is widely accepted that feedback and assessment are critical in supporting and promoting learning, and that when used effectively, can motivate and influence students in terms of what they choose to learn, the effort they apply and depth of the learning that results (Rust et al, 2005; Struyven et al, 2005; Laurillard, 2002). By providing staged opportunities to reflect on competency levels, carefully designed and fully integrated assessment structures can provide a clear measure of the extent of current learning, and encourage future progression (Challis, 2005; Gibbs and Simpson, 2005). Meanwhile, a constructivist approach to feedback will ensure it is delivered in a timely, targeted and responsive manner to address individual learning needs, and enable students to make explicit use of this to promote ongoing progress.

Over the last decade, recognition of the potential that formative assessment can offer to promote learning has steadily grown (e.g. Peat and Franklin, 2002), and although it can vary greatly from short, discrete activities linked to specific learning experiences, to being the entire assessment framework for a course, the pedagogical justification for employing this approach is generally linked to promoting various qualitative learning skills. These include: an enhanced motivation to learn; a sense of control over the learning; increased levels of self-confidence; improved awareness and recognition of competency; and a stronger sense of self-regulation on how the learning experience progresses (e.g. Cassidy, 2007; Miller, 2009). From the tutors perspective, formative assessment can also provide opportunities to determine the thought processes employed by students when tackling different tasks (Miller and Lavin, 2007; Ross et al, 2005), and so direct subsequent teaching practices.

Constructing a formative framework to support and promote learning

In the present mass education environment, with its associated increasing student numbers, emphasis on widening participation, the desire to enhance graduate employability skills and the provision of more flexible study options, providing individual formative feedback while simultaneously maintaining a sense of quality in the learning experience, places increasing demands on staff time and capabilities. Furthermore, given that an individual will only develop as far as their personal capabilities permit, extension beyond this requires some form of timely and targeted interventionist support. This needs to afford the individual a chance to develop, apply and test new learning, as well as offer further direction at crucial points in their learning pathway, targeting specific individual needs.

Commonly referred to as 'scaffolded learning' this concept is the basis of Vygotsky's principle of social interaction (1978), in which a constructivist approach is used to support and direct learning and teaching reactively (e.g. allowing the learner to engage with and use support embedded in the learning resources) and proactively (e.g. pre-

empting potential difficulties and ensuring structured solutions are available when required).

A practical solution to address all of these issues is available through the opportunities provided by ICT and the development of various e-assessment tools, and it was from this perspective that the student online formative assessment (SOFA) framework was designed, to:

- provide a 'safe', formative learning environment in which students could test their depth of learning and application, and develop a sense of personal strengths, weaknesses and achievements;
- use a constructivist learning approach (that was goal-directed and knowledge-building) to offer appropriate levels of flexible and timely support to students, that also offered a reliable and realistic method of testing academic progress at predetermined and self-selected points throughout the academic year; and
- encourage students to become more self-confident and motivated learners, who recognised the value of integrating learning from different resources and were aware of how they were progressing.

For an online environment to scaffold learning effectively, it needs to be logistically, technologically and pedagogically fit for purpose. Furthermore, each user needs to recognise its potential value in terms of supporting and promoting learning extrinsically (e.g. improving results) as well as intrinsically, in terms of developing more self-reflective learners who can adapt their practice by critically evaluating current skills and recognising future potential (Cassidy, 2007).

THE STUDY IN CONTEXT

This study was funded by the Centre for Online Learning in Maths, Science, Computing and Technology (one of UK's Centres of Excellence in Teaching and Learning), with the primary objective to develop a series of student online formative assessments (SOFAs) for a new upper level 2 undergraduate online and distance learning course in Earth System Science, at the UK Open University (UKOU).

The course, *Our Dynamic Planet* (S279) forms part of the Geosciences programme and comprises of ~300 study hours, completed over 9-months. It is formally assessed by four summative assignments and an end of course open-book examination. The core learning resources consists of two specially written course books, a website (containing an interactive study calendar, additional learning skills resources, and links to the study group and national forums), and a DVD-ROM with interactive multimedia activities.

Data presented in this paper have been collected from the first two presentations of the course, in 2007 and 2008. As the primary objective was to review student practices and gain an insight into their perception of their learning, the data has *not* been subjected to empirical statistical analysis, with all conclusions based on qualitative interpretations.

The Student Online Formative Assessments (SOFAs)

There are eight SOFAs associated with Book 1, the first seven h are linked to a specific chapter, while SOFA 8 consists of various revision options, consisting of a random selection of questions from across all seven chapters, or focusing on specific learning skills (e.g. mathematical questions, working with diagrams, using geological processes).

Each SOFA consists of ten interactive questions (the majority of which contain exchangeable variables), created using *OpenMark*, a web-based system developed within the UKOU. *OpenMark* permits up to three attempts to correctly answer each question, offering instantaneous and targeted feedback after each attempt. Each of the SOFA questions has been designed to test knowledge and understanding of a particular subject as well as demonstrate various cognitive, key and practical skills. The final feedback is linked to the course learning outcomes, stating the level of competency that has been demonstrated; there are no numerical grades. There is no limit on the number of times a student can complete a particular question or entire SOFA, with students encouraged to use the SOFAs as often as they wish.

As the style and extent of interaction with SOFA 8 was very different to the other seven SOFAs, only those linked to specific chapters are considered in this paper.

Data collection and methods of analysis

This paper uses two main sources of information: i) quantitative metadata automatically collected by *OpenMark* on the timing, frequency and extent of SOFA usage by all students in the 2007 and 2008 presentations; and ii) quantitative and qualitative information extracted from 'Question 11', an online questionnaire consisting of a series of short multiple choice questions and an open text feedback box, located at the end of each SOFA. It is important to bear in mind that as only a subset of students opted to complete the questionnaire, the views expressed may not be representative of the entire cohort of students from each year.

In addition to reviewing the student cohorts as a whole, comparisons between actual usage and perceptions of the value of each SOFA have been made against gender and the final grades attained (used to indicate the academic ability of an individual), to check for any significant correlations.

COMPARISON OF STUDENT COHORTS

Active registrations for the two presentations consisted of 450 students in 2007 (comprising of 218 [48.4%] females and 232 [51.6%] males) and 313 students in 2008 (comprising of 137 [43.8%] females and 176 [56.2%] males). Examination of personal records confirm the student populations on both presentations were similar in terms of their range of prior educational experiences (varying from no declared higher secondary qualifications to completed tertiary degrees), current academic abilities (based on prior course completions where appropriate), employment status, age ranges, declared

disabilities and gender. On this basis, it was predicted that any significant variance observed in the style and extent of usage, or in the perceived value of the SOFAs as a useful learning tool between these two cohorts would not be due to differences in the 'average' student type, but could be attributed to some other factor affecting learning.

RESULTS AND IMMEDIATE DISCUSSION

The following results are based on quantitative metadata automatically collected within *OpenMark*.

Usage and style of interaction

Comparison of data from the two presentations reveal that overall, a similar percentage of students attempted at least one or more of the SOFAs at some point during the course (59% in 2007 versus 61% in 2008), with the overall percentage of students using each of the SOFAs declining steadily from 52-54% (SOFA 1) to 19-21% (SOFA 7) of the registered student population (Table 1).

Year	SOFA1	SOFA2	SOFA3	SOFA4	SOFA5	SOFA6	SOFA7	Overall users
2007	52%	16% ¹	31%	26%	24%	21%	19%	59%
2008	54%	38%	32%	30%	29%	23%	21%	61%

Table 1: Comparison of the number of individual users (as a percentage of registered students) who accessed the assessments at least, presented by SOFA and as a total percentage for the entire course. (¹The interactive version of SOFA 2 was delayed in 2007 until after the intended scheduled study period. Those students who did return to use it did so primarily during the end of course revision period, with a smaller number also using it at the end of Book 1.)

No difference was identified between the two presentations on how students engaged with the sets of questions within any of the SOFAs. In both years, the number of individual users attempting each question typically decreased slightly from question 1 to 10, while the number of times each question was completed remained relatively stable, equivalent to approximately twice the number of active users.

In relation to timing of use, the majority of students preferred to engage with each SOFA at the first scheduled study period (i.e. immediately after completing the related chapter), viewing and immediately answering each question sequentially, rather than viewing all of the questions before choosing to answer some or all of them in the order that best suited their individual needs. The number of students who interacted with a particular SOFA for the first time after the initial study period was relatively small, but showed a slight increase from ~3-6% for SOFAs 1 – 7.

Analysis of submitted answers highlighted a subtle change in practice as some students became more familiar and comfortable with this learning environment. Rather than attempting to answer a question, spurious responses were repeatedly submitted (e.g. random letters, numbers or no entry) to reveal the final solution and associated feedback on how it should have been attempted. These students then immediately

repeated the question (with the system automatically changing variables to present the students with a 'new version'), which they approached in the expected manner, submitting more plausible answers. Students who used this strategic approach tended to do so for the more challenging questions rather than use it as their default method.

Repetition of SOFAs – impacts on learning

In terms of repeated use, students who attempted less than five questions in a particular assessment were less likely to return to it, whereas students who completed five or more questions were more likely to repeat the assessment during the final revision period. Very few students chose to complete individual SOFAs at the mid-year point (end of Book 1), with more (15-13% of registered students) preferring to use SOFA 8. Students who did complete a particular SOFA at each of the three suggested study periods predominantly completed all ten questions at least once each time they interacted with the assessment. Very few students opted to complete any of the SOFAs at other times during the course.

Students who repeated a particular SOFA either during the first sitting or during the revision periods, generally took a similar amount of time to complete each assessment, although the number of attempts required to correctly answer each question typically decreased. Repeated errors associated with numerical manipulations, incorrect presentation of scientific data and inappropriate levels of accuracy also decreased.

Some students chose to repeat individual questions and/or entire SOFAs numerous times within a single sitting, submitting plausible answers for the majority of attempts. As these students only tended to progress to the next question once they had returned to the first set of variables or had managed to repeatedly answer the question correctly at their first attempt, the presumption is they were using the SOFAs to thoroughly test their understanding and application by making full use of question variables, reinforcing learning and intrinsically boosting their confidence.

In contrast, deteriorating levels of positive engagement were noted in a small number of students who also opted to repeat a question after initially getting it wrong, but who failed to make progress. Although early repeated attempts revealed the students tried initially to get the right answer, repeated errors and misunderstandings resulted in the plausibility of subsequent attempts decreasing, until only spurious answers were entered for each question. These students typically failed to complete the SOFA and often did not return to attempt subsequent assessments.

Influence of gender and academic ability on SOFA usage

A slightly higher percentage of female students from across the academic spectrum used at least one SOFA in 2007 (65%) and 2008 (68%), compared to the male student population (57% in 2007 and 58% in 2008), inferring that female students may have a slightly higher propensity to engage with self-assessment than their male counterparts.

A correlation was also noted between the final course grade achieved by particular students and their level of engagement with the SOFAs, such that, of those who achieved a high level pass, female students were x8 as *more likely* and male students x4 *more likely* (x5 overall) to have engaged with at least one SOFA. Students who achieved a comfortable pass were between x1.5 to x2 *more likely* to have engaged with at least one SOFA (with this slightly more prevalent for female students), while those who achieved a bare pass or who failed the course, were x2 to x3 *less likely* to have engaged with any of the SOFAs. Although no correlation was made between SOFA usage and student withdrawals in 2007, in 2008, of those who withdrew from the course, slightly more (x1.5) had *not* engaged with any of the SOFAs.

Analysis of the total number of assessments completed by individuals on the basis of final grade attained (Table 2) reveals that in 2007, students who obtained a high level pass were *more likely* to have completed six or more SOFAs (with female students in this grouping completing slightly more SOFAs than their male counterparts). In 2008, the number of students in this group who completed seven or more SOFAs rose significantly. In contrast to the high achieving group, the majority of students who obtained a comfortable pass were more likely to have completed between one to three SOFAs (although a significant number also completed ≥ 7), while the academically low achievers (bare pass to fail) were more likely to have completed only one or two SOFAs (with females generally completing more than their male counterparts). Students who decided to withdraw at some point during the course generally engaged with no more than one SOFA (although a small number of these students continued to complete additional SOFAs after they had officially stopped studying). As a whole, the total number of students who used the SOFAs within the three lower grade bands showed an increase between 2007 and 2008.

Number of SOFAs completed <i>(% of user/non-user grouping)</i> /final grade achieved		0	1	2	3	4	5	6	≥ 7
High pass	2007	11	11	11	5	9	5	9	40
	2008	11	6	0	6	0	0	3	75
Comfortable pass	2007	32	19	10	7	5	6	9	13
	2008	29	20	10	4	6	9	6	17
Bare pass to fail	2007	59	21	7	1	4	0	2	6
	2008	50	21	8	5	2	0	5	10
Withdrew	2007	65	22	7	3	3	0	1	0
	2008	53	26	8	6	8	0	0	0

Table 2: Comparison of number of SOFAs completed by individual students against the final course grade achieved in 2007 and 2008. Numbers are shown as percentages of students within each grade band (i.e. 75% of students who attained a high level pass in 2008 completed ≥ 7 SOFAs). (The ' ≥ 7 ' includes students who did all seven chapter SOFAs and/or also completed SOFA8.) The percentage of students in each grade band who did not use any SOFAs is also shown.

Although this data appears to suggest a correlation between SOFA usage and the final grade achieved, this is not a proven fact, as additional factors may have influenced the

final grade achieved; this relationship may actually be symptomatic of the fact that academically more able students are more likely to avail of learning resources that can improve their performance further. To prove whether SOFA usage does have a positive impact on grade attained (and on retention), comparisons between usage and prior education achievement need to be made, to determine whether an improvement in performance has occurred.

Perceived value to learning – ‘Question 11’ responses

Students were asked to provide feedback on their overall perceptions of each SOFA via a structured questionnaire - ‘Question 11’, at the end of each assessment; 627 questionnaires were completed in 2007 and 491 in 2008. Of those who expressed a preference, ~98% of students agreed each assessment was useful to their learning; eight students in 2007 and five in 2008 disagreed, with some choosing to qualifying this by describing specific mathematical problems encountered with some questions (typically misunderstandings of significant figures and manipulating equations) in the open text feedback box.

Students were also asked to select from a list of qualifiers which statement(s) best fitted their perceived value of the SOFAs. Responses were very similar for each of the SOFAs and between the two presentations (Table 3), with students rating the assessments as most useful for ‘testing understanding’, ‘revision’ and ‘measuring progress’ while actively studying the course. This order changed slightly during the two revision periods with ‘revision’ and ‘testing understanding’ becoming the predominant top two reasons.

Perceived value	2007			2008		
	Overall (%)	Scheduled (%)	Revision (%)	Overall (%)	Scheduled (%)	Revision (%)
tested understanding	31.5	33.1	27.7	29.7	29.5	30.1
useful for revision	31.5	26.2	44.9	30.5	26.8	40.0
measure progress	21.4	22.9	17.6	21.7	23.3	17.5
made learning outcomes more apparent	11.7	13.6	7.1	12.6	14.1	9.0
pace learning	3.8	4.2	2.7	5.5	6.3	3.4

Table 3: Summary of responses to the perceived value of the SOFAs, to individual student learning. Values are shown as percentages of total number of responses received for each time period specified.

Although only ~12% of students found the SOFAs helpful in making the course learning outcomes more apparent, this may have been due to the positioning of the questionnaire, as students were asked to respond before they had received the final learning outcomes based results for each SOFA. (However, although the feedback after each question made explicit reference to the learning outcomes assessed, students typically acknowledged that they either did not read this part of the feedback or did not recognise how it linked to their learning.)

Free comments

A total of 113 written comments (from 60 individuals in 2007) and 98 comments (from 45 individuals in 2008) were submitted via the free-text comment box. These have been broadly categorised according to style as: positive (~25%); neutral (~29%); negative (25%); and suggestions (~21%). The main subject of each comment was used to subdivide these further according to whether they relate to: i) queries about specific questions and/or the course materials; ii) reflections on the student's sense of personal progression; iii) issues associated with technical aspects of the SOFAs, or while working in a web-based environment; and iv) comments about mathematical concepts (Table 4).

Classification /Subject	Positive		Neutral		Negative		Suggestions		Total	
	2007 (27%)	2008 (23%)	2007 (27%)	2008 (31%)	2007 (24%)	2008 (27%)	2007 (22%)	2008 (19%)	2007 (113)	2008 (98)
Questioning	8	8	23	28	26	17	27	9	84	62
Reflection	32	33	10	17	17	13	0	4	59	67
Technical issues	2	5	6	4	6	2	8	7	22	18
Mathematical issues	6	10	10	6	6	5	4	6	26	27

Table 4: Summary of the number of open feedback comments submitted to 'Question 11' for Book 1 SOFAs, classified according to the style and main subject of each comment.

Negative comments were often emotive, referring to perceived difficulties and errors or in relation to the individual's grasp of concepts and the skills being assessed, e.g.

Mathematical questions - very frustrating as I have the method right, but may get a significant figure wrong or miss a step - this cannot be seen, so [the quiz] just says wrong...[2008 student]

In contrast, positive and neutral comments tended to be more reflective, with the student often attempting a sense of dialogue, seeking acknowledge and/or some level of reassurance that they were progressing appropriately. Many positive comments also contained descriptions of how the SOFA or particular question had helped the student to recognise personal strengths, weaknesses or improvements in their learning, as well as what strategies they intended to employ to make further progress, e.g.

This is a great way to test what has been learnt and is a great revision tool!! I now know where I have gaps in my knowledge and also learnt some things which I didn't pick up when reading the book. You don't always appreciate what you're reading and its significance until you try and apply it. [2007 student]

Comments in the form of suggestions tended to be more instructional, highlighting actual and perceived errors, as well as suggesting ways of improving the system or

requesting additional feedback, e.g.

Instead of saying one or more of your answers are incorrect it should tell you exactly which ones are wrong before you have your second attempt. [2008 student]

Mapping comments against gender and grade demonstrated that students (both male and female) from the higher academic brackets were more likely to comment that those from the lower brackets. In contrast, no differences in the style or main subject of the comments given were found in relation to gender or grade.

SUMMARY CONCLUSIONS

Overall, results from both presentations are similar and allow them to be treated as a single entity indicative of how an 'average student' will engage with this online formative assessment tool. Although no obvious gender differences in the mode of engagement or perceived benefits to learning were identified, female students across the academic levels were slightly more likely to use the SOFAs than the male students. Whether this is due to male students being more self-confident in their academic abilities, perceiving formative assessment to be non-essential, or due to them being less willing to allocate time to activities that do not have an extrinsic value (i.e. summative grades), is uncertain and requires more detailed investigations beyond the scope of this study. It is however an issue that should be addressed when considering using formative assessment.

Students who are academically more able and/or who regularly use reflective practices are more likely to engage with formative assessment to test the effectiveness of their learning, enhance self-confidence and to provide motivation. Furthermore, these students are more willing to accept feedback irrespective of whether its content, i.e. positive or highlighting weaknesses in current knowledge and/or skills. They are also more likely to use this feedback to target future learning. More academically able and self-confident learners also tend to be more persistent in their use of formative assessment, and are equally likely to question the validity of assessment as reflect on the validity of their own approach when encountering aspects that are unclear or perceive incorrect based on other learning.

Timeliness of the assessments was apparent in comments from students who perceived the SOFAs as their 'own' resource to use as and when they wished, with repeated use enabling an iterative approach to learning in which they could apply, test and reflect on progress within this 'no risks' environment. In addition, a strong motivator to learning flagged by many students was the desire to see an improvement in the final result and irrespective of whether this showed a decrease or overall increase, these students continually stated a desire to improve.

In contrast, academically vulnerable students are less likely to engage fully with formative assessment, and rather than use these opportunities to improve current competency levels, are more liable to adopt a surface approach to learning,

concentrating their time and effort on core materials and summative assessments. Furthermore, those that do engage with the formative assessment tend to favour the extrinsic aspects such as whether or not they answer questions correctly and on the first attempt, while continued failure to complete questions or assessments successfully results in a cumulative negative affect, demotivating the students and reinforcing the gaps in their knowledge, rather than providing a means to direct future learning.

Formative assessment can therefore have one of two effects: to provide scaffolding to enable students to recognise current competencies and to use this to direct future learning and create a sense of improved academic ability; or to act as a barrier to learning, reinforcing current deficits in knowledge and demotivating the individual from wanting to or feeling able to make any progress.

In conclusion, for some students, formative assessment provides an effective learning resource that produces positive academic gains associated with the promotion of self-confidence, increased motivation to learn and improved levels of self-esteem. However, for others it can result in an increasingly negative experience, culminating in a demotivation to learn and increasing levels of self-doubt. As such, for any formative assessment tool to work effectively, it needs to be carefully integrated into the whole learning experience and be developed in such a way that the majority if not all of students, irrespective of their academic abilities and self-perception, can recognise some sense of worth that will help them to succeed in their learning, either extrinsically (e.g. simply getting the right answer), or for more intrinsic reasons (to become a deeper, more reflective and more able learner).

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