Using Technology to Enhance Assessment and Feedback: A Framework for Evaluating Tools and Applications

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ABSTRACT
Although assessment and feedback are very important aspects of teaching and learning it has been regularly reported that there are issues with their practice. While research has shown ways to enhance assessment and feedback, and best practices have been established, various challenges, such as limitations on time and resources, make implementing such improvements difficult. Consequently, this paper considers the use of technology for supporting teaching, assessment and feedback to improve working practices and the student experience in a time and resource efficient manner. Using a feature analysis evaluation technique, this paper proposes a comparison framework for reviewing technological tools/applications that can be used to assist teaching, assessment and feedback. By providing solid rationale, this framework has the potential to enhance decision making when choosing suitable technological solutions to improve teaching and assessment, and to enhance the learning experience.

CCS Concepts
• Applied computing → Education • Social and professional topics → Student assessment • Information systems applications → Decision support systems

Keywords
Educational Technology; Assessment; Assessment for Learning; Feedback; Feedforward

1. INTRODUCTION
Assessment and feedback are very important aspects of teaching and learning [10, 22]. In recent years there has been a great interest in, and immense scholarly writing about, assessment and feedback [6, 24, 29]. However, research [6, 13, 22, 23] has shown students are frequently dissatisfied with assessment and feedback and commonly ignore feedback despite the significant effort staff put in creating useful personalised feedback.

Alternative approaches and best practices have emerged that are designed to improve assessment and feedback practices and enhance the student experience which could help with such problems. For example, the use of feedforward (forward looking feedback) is highly recommended as it makes feedback more valuable by including a focus on the future, providing guidance for enhancing future work and learning [12, 16]. This should be used in addition to traditional feedback with its past and present focus, explaining the standard of work and student progress, as both types are valuable [12, 16]. As another example, using an assessment for learning approach is recommended, as opposed to the classic assessment of learning approach, to focus on using assessment to aid learning [5, 20, 31].

However, while research has shown ways to enhance assessment and feedback, and best practices have been established, various challenges, such as limitations on time and resources, make implementing such improvements difficult [6, 13]. Thus, the challenge is to find ways of enhancing assessment and feedback practices, which engages students and shows them the value of feedback received and encourages using it, in a manner that is feasible given the difficult Higher Education (HE) environment.

Consequently, this paper considers the use of technology for supporting teaching, assessment and feedback to improve working practices and the student experience in a time and resource efficient manner. This paper contributes to the literature by proposing a comparison framework for reviewing technological tools/applications that can be used to assist teaching, assessment and feedback.

The remainder of the paper is outlined as follows: Section 2 presents a literature review on assessment and feedback, including their importance, current practices, best practices, and challenges that affect ability to make improvements. Then, in section 3, we consider whether technology can help solve identified problems, followed by related work in section 4. Next, in section 5, we propose a comparison framework for reviewing technological tools and applications that can be used to assist teaching, assessment and feedback. Finally, in section 6, conclusions are drawn, and suggestions are made for future work.

2. ASSESSMENT AND FEEDBACK
Although assessment and feedback are very important to education it has been regularly reported that there are issues with their practice. As Boud and Molloy [6] explain, assessment and feedback consistently gain lower satisfaction scores from graduates compared to other aspects of their courses (programmes), which is shown in both the UK's National Student Survey and Australia's Course Experience Questionnaire. Likewise, the UK's annual Student Academic Experience Survey [23] shows some low, and in some cases declining, student satisfaction results regarding feedback, including the amount, timeliness, and value of feedback. Also, Murtagh and Baker [22] found, from both their own survey and literature, that students are frequently dissatisfied with feedback received, with problems such as lack of clarity, usefulness and constructive comments.

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ICEIT 2020, February 11-13, 2020, Oxford, Oxfordshire, England.
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DOI: http://dx.doi.org/xx.xxxx/12345.67890

It is also often noted that students have little interest in feedback received and do not make proper use of it, or ignore it completely, and are typically only interested in the mark received [13, 22]. This is particularly infuriating for educators who tackle large workloads to spend significant time creating useful personalised feedback designed to aid student's learning [13, 24].

However, it is not surprising students ignore feedback if they are dissatisfied with it and see little value in it. So, the challenge is to create a learning environment that enhances the assessment experience and shows students the value of feedback and encourages its use.

2.1 Best Practices and Alternative Approaches

Given the need to enhance assessment and feedback practices we now look at some best practices and alternative approaches to consider a way forward.

Assessment has two main purposes, to facilitate certification and to aid learning [4]. Due to the importance of grades and certification, to verify whether desired learning has occurred, assessment of learning (assessment for certification) has traditionally been the dominant approach within education [5, 20]. However, assessment is not all about certification and it should also aid learning [4, 15]. This is the focus of an alternative approach known as assessment for learning which is beginning to gain acceptance and prominence and is highly recommended [5, 31].

2.1.1 Assessment of Learning

Assessment of learning occurs once a unit of work/instruction is complete with a summative assessment approach used to formally check whether desired learning has taken place [20, 21]. It establishes and explains how well students have met desired goals/criteria (curriculum outcomes) to award marks/grades towards certification [20, 21].

As assessments evaluate learning achieved from a learning experience, such as a taught unit (module), feedback will relate to that experience and the student's understanding of areas/topics covered [3, 25], therefore, feedback will be useful for supporting work and learning covering those areas/topics. However, when assessment of learning is used, being summative and final, the current unit of work/instruction is complete when assessment occurs, so feedback received cannot be used with/for it [20, 31]. Therefore, feedback can only be used with later learning opportunities, but future studies may not cover the same or related topics/content as HE courses (programmes) tend to quickly move on to cover new areas [4, 31]. Thus, the value of feedback and opportunities to use it is limited, simply assessment occurs too late to have a significant impact on learning [5, 31].

While certification is important just focusing on it neglects the value of using assessment to aid learning, this is addressed by the alternative assessment for learning approach [5, 31].

2.1.2 Assessment for Learning

Assessment for learning focuses on the use of assessment to aid learning, making use of both formative and summative assessment [5, 31]. Rather than treating assessment as an end point, done when current learning is meant to be complete (such as at the end of a unit/module), assessment is used/seen as part of the learning process [21, 31]. Accordingly, feedback should be used throughout the learning process to help improve both current and future learning and work for greater learning opportunities [5, 31].

Formative assessment is considered important for aiding learning as it facilitates learning via assessment during the unit of work/instruction and can be used to prepare students for summative assessment [4, 25, 31]. Feedback focuses on progress made and provides guidance on areas for improvement to assist with learning and work within and ideally beyond the unit of work/instruction [4, 31]. Therefore, not only is it useful for current work/learning but also for future learning, helping students develop lifelong learning competencies which is a goal of assessment for learning [4, 31]. Formative assessments designed to help students with summative assessment, such as assessing draft work and tasks that relate to or form part of summative assessment, are particularly useful [12, 31]. When a unit of learning/work is complete and formal assessment is required for grading/certification purposes summative assessment can be used [3, 31]. The difference here though, compared to an assessment of learning approach, is students receive feedback during the learning process, not just after it, when they can make use of it to support learning and summative assessment.

Assessment for learning covers the whole assessment process, it is not restricted to only formative assessment as summative assessment is also valuable for aiding learning [31]. With this approach, in comparison to assessment of learning, summative assessment is not limited to purely verifying ability for certification purposes as it can, and ideally should, also be used for aiding learning [15, 31]. While such feedback is of limited use within the current unit (module) being studied, as summative assessment tends to occur at the end of a unit, educators can make summative feedback relevant for later work and lifelong learning [3, 15, 31]. This could be done by, for example, providing useful feedforward comments; having multiple linked assessed tasks so that the feedback from one task can be used with the next; providing advice for later units; or focusing on lifelong learning [6, 12, 31].

The key argument of assessment for learning is to consider how assessment can be used to aid learning, reducing the focus on assessment purely for certification purposes [4, 31]. Also, while summative assessment is essential it should not be the only form of assessment as formative assessment is also very valuable for aiding learning [4, 31]. Commonly, however, summative assessment tends to dominate assessment practices, often focussing primarily on certification, with formative assessment given much less consideration and usage [4, 31]. Thus there is need for a better balance between summative and formative assessment, with a focus on aiding learning [4, 31].

2.1.3 Best Practices

This assessment for learning approach follows best practice for feedback by not only providing information on the standard of students' work and progress (a past and present traditional feedback focus) but also by providing guidance to aid future work and learning (a future/feedforward focus) [12, 16]. Also, feedback occurs throughout the learning process when students have a chance to make use of it, rather than solely after the unit of work/instruction is complete when there is limited opportunity to use it [21, 31].

This approach, by focussing on making use of feedback, helps meet students' desire to see the relevance and applicability of feedback, and should help tackle the problem of students seeing little value in feedback and commonly ignoring it [13, 22, 23, 27].

Thus, both formative and summative assessment are key to learning: formative assessment provides advice and knowledge to

aid learning and explains progress towards learning goals and task completion; and on completion of a unit of work/instruction summative assessment establishes what has been learned and can guide future learning [3, 4, 31].

2.2 Challenges

However, while it is recognised that using an assessment for learning approach, with both formative and summative assessment used to aid learning, is worthwhile [5, 31] there are various factors that make its implementation difficult.

Firstly, growth in student numbers caused by mass higher education, without sufficient funding to match, has reduced resources per student, such as staff time and availability, and has increased staff workload including additional marking pressures [6, 13]. Secondly, the use of modularisation and semesterisation in HE, splitting courses into smaller chunks, reduces the time available for assessment [13, 31].

As assessments require time for students to complete work and staff to mark it, and given this situation reduces both, the amount of assessments it is feasible to offer is limited [7, 13]. It is difficult to offer multiple pieces of assessment within a unit (module) and consequently the number and regularity of assessments in HE has reduced, which reduces opportunities to learn from and make use of feedback [6, 13]. This has the biggest impact on formative assessment as, due to the need to ensure learning has occurred for certification, summative assessment is prioritised over formative assessment, with the latter commonly being marginalised [5, 31]. Plus, due to modularisation and semesterisation reducing the length of units it is difficult to fit formative assessments into the limited time available [7, 30]. There is limited time for students to complete formative assessments (especially multiple pieces), staff to mark them, and then for students to make use of feedback within the unit, such as using feedback to adjust work required for summative assessment [7, 30].

This situation neglects the valuable learning opportunities a formative assessment for learning approach provides [5, 31]. So how do we tackle the problems preventing greater use of formative assessment to aid learning?

3. CAN TECHNOLOGY HELP?

Technology could potentially help overcome these problems and support teaching, assessment and feedback to improve working practices and the student experience in a cost, resource and time efficient manner. The use of technology to support education and assessment is a popular research topic, and we present a few relevant examples.

The use of technology has the potential to aid and enhance assessment for both formative and summative purposes. For example [2, 9, 12, 31]:

- computerised assessment and feedback where software automatically evaluates the value of work and provides feedback/feedforward, without the need for staff time, can provide additional and timely feedback, ideal for formative tasks;
- the use of audio or video feedback can enhance the feedback experience helping learners understand feedback and increasing engagement;
- and the use of online tests and in class personal response systems can quickly gauge students understanding and aid classroom engagement.

There are many online tools that support online learning, assessment and feedback, and Virtual Learning Environments (VLEs), also known as Learning Management Systems, provide built-in tools [14, 35]. For example, tools such as Turnitin integrate well with many VLEs and provide support for different types of feedback such as rubrics and audio feedback [32]. Turnitin can also generate similarity reports which are useful for identifying obvious plagiarism [32].

There are many potential challenges and problems with the use of technology. For example, there is a risk that technology could complicate rather than simplify processes outweighing the potential benefits of its use [36]. Also challenges, such as technical difficulties, time restrictions, lack of knowledge and skills required to utilise technology, and absence of consideration of how to make best use of technology for education purposes, can affect appropriate utilisation of technology restricting its potential to enhance education [33, 34].

Therefore, to fully realise the benefits of technology usage within education, it is necessary to facilitate the choice of appropriate technological tools/applications which can address these challenges, provide a benefit to education and encourage utilisation without undue complexity. This can be aided by the defining of criteria for evaluating such tools and we propose a comparison framework for tackling this problem later in this paper.

4. RELATED WORK

A recent survey conducted by the Universities and Colleges Information Systems Association [34] presents an overall picture of Technology Enhanced Learning (TEL) usage in HE to support learning, teaching and assessment. This is complemented by various other studies of TEL in HE [for example, 8, 17].

Leal and Queirós [19] propose a comparison framework for Learning Management Systems and present a survey of existing standards and illustrate their work with well-defined scenarios; however, their focus is purely on interoperability.

Kumar and Owston [18] discuss the importance of evaluating the accessibility of e-learning methods to ensure students do not encounter barriers to accessibility. Their study found that student-centred methods are vital for e-learning accessibility evaluation as is ensuring students understand both e-learning content and how to use e-learning interfaces.

To the best of our knowledge, there is no existing framework in literature to compare existing technological tools/applications for improving teaching, assessment and feedback and to support the decision-making process when choosing the most suitable solution. Hence, our work focuses on features to compare existing solutions and proposes a comparison framework to assist this process.

5. COMPARISON FRAMEWORK

A feature analysis, as described in [26], was conducted in this research. A series of focus groups of academics at Bournemouth University were used to establish a list of generic features that could form the basis of a general comparison framework to use when selecting technological tools/applications to enhance teaching, assessment and feedback. The framework's criteria (i.e. features that are considered worth assessing) were established based on the outcomes of these focus group meetings, the experiences of the authors, and literature reviewed. The major categories for criteria are shown in Figure 1.

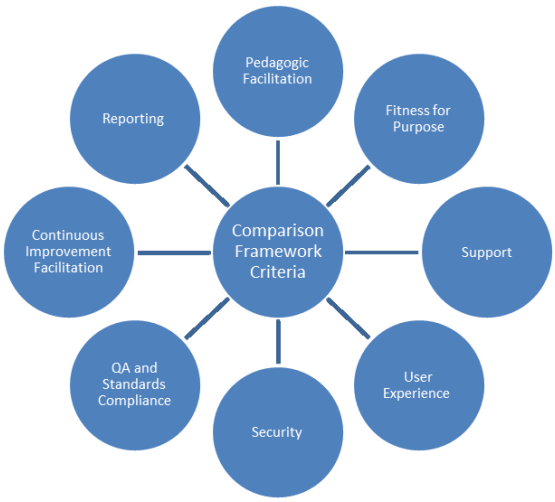

Figure 1. Categories for the criteria for comparing technological tools and applications.

Each of these categories contains a set of criteria as defined below:

Pedagogic Facilitation
- Support for different teaching styles
- Support for different assessment styles
- Support for different submission methods
- Ability to manually add Feedback/Feedforward
- Automatic generation of Feedback/Feedforward
- Progress tracking

Fitness for Purpose
- Solution completeness
- Integration with existing systems used
- Connectivity to external systems
- Support for Online/Offline working
- Performance
- Availability and portability
- Scalability
- Robustness
- Cost effectiveness

Support
- Official support
- Community support
- Quality of documentation
- Longevity and update frequency
- Availability of teaching materials
- In-house experience to support and setup

User Experience
- Usability
- Accessibility
- Motivational potential

Security
- System
- Content
- Access control
- Privacy

Quality Assurance (QA) and Standards Compliance
- Legal, Ethical, Social and Professional Issues
- Standards/Guidance
- Audit Trail

Continuous Improvement Facilitation
- Extensibility
- Telemetry

Reporting
- Collecting and analysing data
- Exporting data

The following sections explain these proposed categories and criteria of the comparison framework. These criteria are only intended as a starting point and will need to be refined when the framework is applied to a specific context.

5.1 Pedagogic Facilitation

The pedagogic facilitation category covers aspects related to support for learning and assessment. It focuses on support for different teaching and assessment practices, including identified best practices, and student performance/progress. As discussed above, following best practices is beneficial and solutions that can support this are desired.

The support for different teaching styles criterion is about how well the technological tool/application (henceforth referred to as "the tool") supports different ways of educating students. The support for different assessment styles criterion is about how well the tool satisfies different formative and summative assessment types such as exercises, assignments, tests, and groupwork. Whether the tool supports different submission methods, such as large file uploads, code uploads, and multiple file types, is also considered.

Support for providing feedback/feedforward to students is another criterion area, which can be either manual or automatic. The manual feedback/feedforward criterion is about, given the teaching approach, how well the tool facilitates reviewing and commenting on students' submissions. The automatic feedback criterion evaluates the availability of automated assessment of work and how useful its feedback/feedforward is to students.

The progress tracking criterion covers built-in dashboards, performance measurement and notifications. This is highly related to the collecting and analysing data criterion of the reporting section.

5.2 Fitness for Purpose

The fitness for purpose category covers aspects related to the suitability of the solution for the organisation. This helps ensure the chosen solution meets user requirements and expectations.

Solution completeness is one of the most important criteria which is used to assess if the tool satisfies all of the requirements of the teaching team. Although this is related to pedagogic facilitation, it covers more than the availability and support for learning and assessment and considers the usability and suitability of the tool as a whole.

The integration with existing systems in use and the connectivity to external systems criterion are also very important. Integration with other key systems, such as student records systems, user authentication systems and VLEs, is important for effective use of technological solutions [19, 35].

The support for online/offline working criterion is about the availability of alternative working styles if there is no internet connection and capability of synchronisation if accessed from different devices. This can be provided via import/export or upload/download features.

Non-functional software requirements such as Performance, Availability, Portability, Scalability and Robustness are also included in the criteria. Cost Effectiveness describes if the cost of deploying and maintaining the tool or service is affordable and should be analysed carefully.

5.3 Support

The support category covers all aspects of support provided for the tool. This was a key concern of the focus groups as a tool is only viable if there is support for its operation and longevity.

Official support refers to the tool or service provider's help and support services. For example, are they accessible any time, do they provide customer support? Community support is about the users of the tools and their active involvement in user forums, blogs or technical support services especially in answering support queries. Quality of documentation is about the quality, completeness and accuracy of user guides, help files, FAQs, tutorials, API documentation, etc.

Longevity and update frequency is about the ongoing maintenance, development and improvement of the tool. It should be clear that the software will continue to be updated (especially for maintaining security), maintained and developed for the foreseeable future.

Availability of teaching materials identifies if there are any prebuilt teaching and learning materials and their usefulness for aiding teaching. In-house experience to support and setup is about the training and in-house knowledge transfer support available to assist the usage of the tool.

5.4 User Experience

The user experience category is about the usability, accessibility and motivational potential of the tool with a criterion for each. It is highly recommended when considering technology or software solutions to consider usability and the user experience as well as human factors in design [1, 11, 26]. For example, is it easy to learn and use the tool? Does it conform to relevant standards and guidelines? etc. This is all about the student and staff experience while using the tool and their motivation to learn or teach using the tool.

5.5 Security

The security category covers the tool/system's security, privacy and access control related aspects. The system criterion is about the tool's trust level and it should be secure without any issues. System security is of great importance to users and organisations and appropriate security precautions should be in place to provide confidence in the system [11, 28]. Storage of content (content criterion) should be secure and appropriate levels of user access (access control criterion) should be in place [28]. Privacy of user's data (privacy criterion) is also important so should also be taken into consideration [28]. Although organisational requirements may change, these criteria are very important and should be assessed in detail.

5.6 QA and Standards Compliance

The quality assurance (QA) and standards compliance category is closely related to security and covers Legal, Ethical, Social and Professional Issues (LESPI) as well as compliance with the relevant standards, guidance, specifications and audit trails. This is essential as the education industry provides services to the public and is well-regulated with strict standards enforced by both government organisations and professional bodies.

5.7 Continuous Improvement Facilitation

The continuous improvement facilitation category is about the extensibility of the tool, flexibility for improvement and adaptation, and the ability to provide telemetry facilities (i.e. measuring the performance/effectiveness of the tool). These are important considerations for enabling the organisation to consider later optimisation and expansion of the chosen tool.

5.8 Reporting

The reporting category covers data collection, analytics, visualisation and data export features. Educators are likely to want to analyse class progress and statistics to guide student support.

5.9 Usage of the Criteria

Each criterion needs to have a weighting assigned to it to determine its relative importance within a specific context. A weighting range of 1-5 (higher values carry more weight) was chosen based on [26]. Ratings are applied to each criterion for each tool, which was also originally done on a range of 1-5. However, in practice it was found that some criteria needed the ability to be rated as unacceptable to the point of ruling out a tool, e.g. the cost is prohibitive. So '0' was added to the range to indicate 'unacceptable' for a criterion, and criterions can be defined as essential. The rating for each criterion is multiplied by its weighting and these values are summed up together to give the overall rating for a tool. If a criterion is set as essential and gets 0 then the tool is ruled out automatically. On the other hand, decision makers can still see the capacity and value of the tool for comparison. These criteria, weightings, rankings etc. can be put into a spreadsheet table to facilitate easier data collection and comparison. Figure 2 shows the top segment of such a table.

Category/Criteria	Weighting (1-5)	Tool 1 Rating (0-5)	Weighting * Rating	Tool 2 Rating (0-5)	Weighting * Rating	Tool 3 Rating (0-5)	Weighting * Rating	Notes
Pedagogic Facilitation								
Support for different teaching styles								
Support for different assessment styles								
Support for different submission methods								
Ability to manually add Feedback/Feedforward								
Automatic generation of Feedback/Feedforward								
Progress tracking								
Fitness for Purpose								
Solution completeness								

Figure 2. Framework table view example - table top view

6. CONCLUSION AND FUTURE WORK

In response to an identified need to enhance assessment and feedback practices, while dealing with challenges making implementing improvements difficult, this paper considered whether technology can help improve working practices and the student experience. A feature analysis [26] was used to propose a comparison framework for reviewing technological tools/applications that can be used to assist teaching, assessment and feedback. By providing solid rationale, this framework has the potential to enhance decision making when choosing suitable technological solutions to improve teaching and assessment, and to enhance the learning experience.

As future work, we intend to evaluate the use of this framework. This will involve showing a potential use for the framework within the context of a computing undergraduate degree course which aims to establish a suitable technological solution to improve the teaching and assessment of its programming units (modules). This will evaluate suitable tools such as Repl.it, GitHub Classroom and Codio.

7. ACKNOWLEDGEMENTS

Our thanks to Melanie Coles from Bournemouth University for her valuable comments and suggestions.

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