IMPROVING QUALITY OF FEEDBACK USING A TECHNOLOGY-SUPPORTED LEARNING SYSTEM

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Abstract

Feedback is a crucial element in the learning process and it can be quite challenging to provide the right feedback upon which students can act upon to improve their learning. Providing proper feedback is even more challenging in contemporary educational environments due the presence of a number of factors such as: changing expectations of students, variety of teaching modes, etc.

Our objective in this study is to develop a scalable technology-enhanced learning approach that provides quality and actionable feedback to students which they can use it to improve their learning. We provide a detailed explanation of the pedagogical foundations of our approach as well as the design and implementation of the technological supporting system. 142 students across three undergraduate IS-related courses were exposed to the new learning approach over a period of 12 weeks. The outcome of this was then evaluated using a retrospective pre-test on several dimensions of feedback. In this paper, we only report the findings related to the quality of feedback. The data is then analyzed using descriptive statistics and the Wilcoxon Signed Rank Test. Results showed that the approach was promising as students found the feedback to be relevant, adequate, timely and generally better than in other courses.

Keywords: feedback, educational technology, retrospective pre-test

1 INTRODUCTION

Feedback is a crucial part of the learning process as the feedback provided to students is often considered to be one of, if not the most influential aspect, of learning and performance. The requirement for instructors to provide quality feedback in a timely manner is a common theme in the educational research literature. In addition to the quality of the feedback provided, students must be given the opportunity to utilise and learn from the feedback.

Providing quality feedback has always been challenging in traditional teaching environments and can be even more challenging to get right in contemporary Teaching and Learning environments due to a number of significant factors: (1) increasing class sizes, (2) desire for personalised learning, (3) multiple modes of teaching delivery (i.e. face-to-face, online, blended etc.), (4) absenteeism and (5) changing expectations of students.

Although technology can be used to address some of these issues, it is well-known that by itself technology is not adequate as it is merely an enabler for any process, be it business processes or teaching and learning processes. Thus, any proposed technological solution to address the issue of providing quality feedback to students should be integrated with solid pedagogical practices. One such current practice is bite-sized learning being increasingly favoured not only by educational institutions but also training providers.

Our aim in this paper is to design an educational intervention to address the issue of providing quality feedback to students to help them improve their own learning. This approach provides students with a means to reflect on and self-evaluate their progress whilst studying for the course and eventually adopt this practice for life-long learning.

2 BACKGROUND

Feedback is important as it plays both an evaluative role as well being an instructive tool for learning and development (Gibbs & Simpson 2004; Hounsell 2003; Lizzio & Wilson 2008; Sadler 2010). For assessments, it is often described as the most influential aspect of student performance (Gibbs & Simpson 2004). The influence feedback has on performance, however, is dependent on the type of feedback delivered and the principles of feedback incorporated**.** There are two main types of feedback: summative and formative.

Summative feedback performs two key functions (Taras 2005). The first function is to deliver to students an assessment of their learning at a certain point in time. The second function is a description of how the mark was derived from the strengths and weaknesses of students' work (Taras 2005). With summative assessment often carried out at the end of a course or unit, students may feel that the feedback is unhelpful, as it does not give them the opportunity to apply the feedback to further assessment (Pokorny & Pickford 2010). Similarly, by using this assessment at the end of the unit, the day-to-day learning of students cannot be monitored by tutors (Guskey 2003). Due to this, the progress of students is not accurately measured and their learning decisions based on this misinformation are not managed. Ultimately this leads to students misinterpreting their abilities, learning needs and progress. This inaccurate information is also passed on to their tutors who subsequently make the same judgments (Stiggins 2002). As a result of this, summative feedback has been criticised as having negative effects on student learning (Yorke 2003).

Formative feedback develops students learning by offering information such as assessment standards, suggestions for improvement and follow up actions in addition to summative feedback (Heritage 2010). Formative feedback, when delivered correctly, realigns students' thinking or behaviour to improve their learning (Shute 2008).

Whilst all feedback is important, the purpose of the feedback must be clear. The purpose of the feedback dictates the distinction between "assessment of learning" (summative feedback) and "assessment for

learning" (formative feedback) (Black & Wiliam 1998). Assessment of learning gives students an assessment of their learning at a certain point in time. Assessment for learning goes beyond this and offers further information to help students develop their learning skills. This is achieved by following the principles of quality formative feedback that are discussed next.

2.1 Principles of Quality Formative Feedback

The original three guiding principles for quality formative feedback (Sadler 1989) were: (1) identifying good performance, (2) showing how current performance relates to good performance, and (3) suggesting follow up actions to close the gap between current and good performance. These were revised and expanded upon to the following seven attempting to better facilitate learning in a modern class. Quality feedback should (D. J. Nicol & Macfarlane-Dick 2006):

1. Help clarify what good performance is (goals, criteria, expected standards);
2. Facilitate the development of self-assessment (reflection) in learning;
3. Deliver high quality information to students about their learning;
4. Encourage tutor and student dialogue around learning;
5. Encourage positive motivational beliefs and self-esteem;
6. Offer opportunities to close the gap between current and desired performance;
7. Provide information to tutors that can be used to help shape teaching.

A detailed explanation of each principle follows next.

Principle 1: Help clarify what good performance is

To successfully complete a task, students must have a firm understanding of the task requirements and the expected quality of work. This understanding however often does not align with the expectations of tutors (Norton 1990). As a result of this misunderstanding, students are unable to accurately assess their performance against the expected outcome (Yorke 2003). When students understand the expectations of tutors, they are able to assess their performance and make adjustments where required. By addressing this principle, it serves as a foundation for the remaining principles to be achieved (D. Nicol 2007).

Principle 2: Facilitate the development of self-assessment in learning

Students, to an extent, provide their own internal feedback through engagement with learning and assessing their progress (D. J. Nicol & Macfarlane-Dick 2006). From this feedback, students are able to re-adjust their learning to align with education goals (Stiggins 2002). This self-evaluation is a key skill that students carry beyond their academic career (Boud 2000). There is a growing concern however, that students rely too heavily on external assessment provided by tutors (Black & Wiliam 1998). When students don't understand the process by which tutors develop feedback, their dependency on external feedback increases in place of developing self-assessment and corrective skills. To use self-assessment to bridge knowledge gaps, students must possess evaluative abilities like their tutor (D. J. Nicol & Macfarlane-Dick 2004). Tutors should therefore not only focus on the quality of their feedback but also on the development of students' self-assessment skills (Boud 2000; Yorke 2003).

Principle 3: Deliver high quality information to students about their learning

High quality feedback directly affects student engagement and learning (Agius & Wilkinson 2014). A commonly raised issue is that students lack quality feedback to help them manage their own learning. They therefore, do not engage with or act upon this feedback. Quality feedback indicators such as timeliness, relevance, clarity and quantity are all factors identified by students as less than satisfactory (Black & Wiliam 1998).

Principle 4: Encourage tutor and student dialogue around learning

Learning is not a one-way communication of information. Similarly, feedback should not be a one-way transmission (D. Nicol 2007). Students should be encouraged to analyse the feedback they receive, discuss it with others and engage the tutor to clarify their understanding (D. Nicol 2007). To be effective, students must not only understand the feedback, they must also act upon the feedback they receive (Sadler 2010).

Principle 5: Encourage positive motivational beliefs and self-esteem

Frequent graded assessments have been shown to negatively impact student learning (Harlen & Deakin Crick 2003). By using non-graded, frequent, formative assessments however, students receive constant feedback guiding them on how to improve. Through this, students continuously adjust their learning based on that feedback (Stiggins 2002). Studies have shown that feedback provided through these assessments has increased learning motivation compared to only being given a grade (Butler 1988). As students' motivation increases, the delivery of material becomes absorbed more efficiently saving time and effort for both tutors and students (D. J. Nicol & Macfarlane-Dick 2006).

Principle 6: Offer opportunities to close the gap between current and desired performance

Students receive feedback from tutors regarding their performance and how it compares to the expected performance (D. J. Nicol & Macfarlane-Dick 2004). Research reveals however that students often find feedback unhelpful and lacking in advice on how to improve (Higgins et al. 2001; Williams et al. 2008). Students require this information because they learn with greater efficiency when they understand their progress and what they could do to improve (Hounsell 2003). This information also acts as a platform for interaction between tutors and students for further feedback, self-monitoring, and self-regulated learning (Heritage 2010).

Principle 7: Provide information to tutors that can be used to help shape teaching

Tutors benefit from formative assessment in which students are involved in the feedback process (D. J. Nicol & Macfarlane-Dick 2006). Through frequent formative assessments, tutors are able to monitor student performance, observe behaviour, discuss progress and understand thought process. This information can then highlight the level of understanding and skills of students. Tutors can then make better decisions using this information as a guide to adapt their teaching (Stiggins 2002).

2.2 Delivering high quality information to students about their learning

Our focus in this study is the third principle of feedback. The quality of feedback is often a disputed topic in literature (D. J. Nicol & Macfarlane-Dick 2004). However, there are suggested strategies by which the quality of feedback can be improved and they are discussed next (D. J. Nicol & Macfarlane-Dick 2006).

Strategy 1. Making sure that feedback is provided in relation to pre-defined criteria

Feedback must be consistent with the requirements of the task. If feedback does not align with the criteria, students are often left to decipher the comments and assess the work for themselves (Pokorny & Pickford 2010).

Strategy 2. Providing timely feedback

With assessment often carried out at the end of a course or unit, students may feel that the feedback is unhelpful, as it does not give them the opportunity to apply the feedback to further assessment. This is also the case when students receive feedback long after submission. Students have had to moe on to future tasks or simply do not recall the thought process in performing the task. They can therefore not align the feedback with the misconception to address the issue and carry that misconception into future work (Pokorny & Pickford 2010) .

Strategy 3. Providing corrective advice

Students receive feedback from tutors regarding their performance and how it compares to the expected performance but this often lacks what is required for students to bridge the knowledge gaps (D. J. Nicol & Macfarlane-Dick 2004). Students require this information because they learn with greater efficiency when they understand their progress and what they could do to improve (Hounsell 2003).

Strategy 4. Limiting feedback to usable quantities

Feedback must be proportional to the task. Providing paragraphs of feedback where a few lines highlighting the misconceptions and suggestions on corrective action would suffice, dilute feedback and key messages are lost in verbose bodies of text. Supplying usable quantities of feedback can be achieved by breaking down learning programs into manageable, assessable units providing feedback for each unit at regular intervals (McGaghie et al. 2010).

Strategy 5. Prioritising areas of improvement.

Where students may have multiple areas of improvement to work on, tutors must be able to focus on high-level skills that underpin the weakness rather than only developing the low level ability leaving the underlying misconceptions unaddressed (D. J. Nicol & Macfarlane-Dick 2006) .

Strategy 6. Providing online tests so that feedback can be accessed anytime.

The increasing size of university classes can limit both the quality and quantity of feedback provided in the traditional class system (Pear 2003). Through the use of online tests, students are been able to continue their studies outside of the classroom at a time that is convenient to them regardless of their location (Richardson & Swan 2003). Using online practice tests with quality formative feedback prior to assessed tests has increased student performance up to 30% across various disciplines.

2.3 Bite-sized learning

Students' ability to absorb and assimilate both learning material and feedback is limited. Tutors must be able to communicate and effectively deliver quality learning without overloading students. Therefore, instruction should be designed to avoid unnecessary additions whilst keeping the content engaging and stimulating. To reduce the effect of overload, it is suggested that learning material be segmented into manageable, bite-sized quantities (Mayer & Moreno 2003). This strategy is commonly suggested through various teaching and learning methodologies. The Personalised System of Instruction (Keller 1968) suggests that instruction should be sequenced into small steps. Similarly, Mastery Learning (Guskey 2007) notes that breaking down a course into small units allows for frequent formative testing at the conclusion of each unit. In all cases, frequent formative testing increases student feedback to correct misconceptions before carrying them into subsequent units.

2.4 Related studies

A study related to this research involving a computer managed learning system (CML) similar to our proposed approach was implemented at Curtin University, Perth Australia (Sly 1999). Researchers sought to improve student learning through formative assessments distributed using a technology-based system. The CML is used to distribute practice tests that are not graded covering as little as 50% of the assessed material with immediate feedback given to students at the conclusion of each test. In this study, groups of students across various disciplines were given optional practice tests available through the CML whilst control groups did not have access to these tests. Students were then given time to act upon the feedback they received to address any identified weakness. Through this research, it was suggested that students assimilated the external feedback provided by the CML to develop their own internal feedback. They could then use this internal feedback to improve their learning strategy for the subject matter.

Another study involved the implementation of a computer-assisted assessment software (CAAS) across two different universities (Bull & Stephens 1999). In this study, researchers wanted to evaluate the

response and acceptance of the system from both staff and students' perspectives. CAAS was used to instantly deliver both formative and summative feedback to students as they completed assessments. At one university, CAAS was piloted with 150 first year psychology students. Students were given a questionnaire to complete both before and after having used the system which indicated they enjoyed using CAAS over traditional assessment methods.

At a second university, results from the assessments were similar for both traditional and CAAS distributions however students showed a preference for the CAAS method primarily due to feedback being returned immediately. Ultimately it was found that CAAS was most beneficial for both students and tutors when used to distribute ungraded formative feedback. Staff reported that using CAAS provided them with more diagnostic information regarding student progress and increased the available time they could spend with struggling students to improve performance.

Both of these studies showed an improved feedback experience through focussing on timely responses however neither study focussed on improving the remaining aspects of quality formative feedback. Through the implementation of our proposed learning approach, it is intended that other aspects of quality formative feedback will be improved upon in addition to timeliness. This should not only support the results of the aforementioned studies but further expand upon them.

3 TEACHING APPROACH AND SUPPORTING SYSTEM

Our proposed teaching approach makes use of pedagogical concepts such as bite-sized learning and focuses on the quality, quantity, and timeliness of feedback. The practice of bite-size learning is ideal for providing these aspects of feedback since dividing class activities into small chunks provides plenty of opportunities to deliver more focused and frequent feedback. Given the traditional lecture and tutorial delivery format of the discipline we teach, namely Information Systems, we focus our learning approach for tutorial work in which students carry out hands-on tasks to learn. Prior to this approach being introduced, students were given small software projects to complete during the weekly tutorials. The learning approach did not seek to overhaul this process. Instead the same projects were broken down into smaller tasks and made available to students before, during and after class. By completing all the tasks sequentially, students completed the original project, and where appropriate, a short test was developed for each task. The purpose of the tests was to allow students to verify their understanding of the tasks and to provide them with feedback.

During tutorial classes (or in their own time outside of classes) students perform bite-sized tasks, and upon completion of these tasks, they self-test their understanding by taking small tests. The tasks range from reading and understanding the current week's lecture, adding a new feature to an existing information system or even developing a small information system. The tests are in the form of five multiple-choice questions with four answer options. Each answer option has specific feedback attached to it. In the case of incorrect answer options, the feedback does not reveal the correct answer. Instead, it explains why the answer option is incorrect and/or gives students hints or directs them to sources that would aid them in determining the correct answer. In the case of a correct answer option, the feedback explains why the answer is correct (in case students guessed the correct answer). That is, the feedback is constructed in such a way that adds value to students to re-take tests multiple times.

Tutors can drive this teaching approach by frequently consulting with students individually and reviewing their results. However, as this is a time consuming and arduous process to be carried out manually, a technological solution is necessary to facilitate the teaching approach, and the obvious choice is a web-based system that can be accessed by students anywhere and anytime.

3.1 The Technological System

The technological system for supporting the teaching approach is a web-based learning system we previously developed as a test-bed for implementing and evaluating technology-enhanced learning systems. The overarching design philosophy for the system is to provide students with access to tasks,

undertake tests and for progress to be monitored by both students and instructors. As a result, the system was nicknamed, the Task-Test-Monitor (TTM) system.

The system is very simplistic in nature. Instructors upload their instructions for tutorial tasks in PDF format while test quizzes are uploaded both in PDF and Excel formats. The questions, answers and feedback contained in the Excel spreadsheet are converted to database records by a web service to subsequently facilitate administering the tests to students as many times as they wish, at any time and from anywhere they wish as well as automate the provision of feedback after each attempt and keep track of results.

The intended usage of the system is for students to perform the tasks in class and on completion of the task attempt the corresponding test to self-assess understanding of the task. On unsatisfactory performance, the expectation is for a student to review the task and re-attempt the test until satisfactory performance (and hence satisfactory understanding of the task) is achieved. This is in line with Bloom's (Bloom 1968) Mastery Learning teaching approach and Keller's Personalised System of Instruction (Keller 1968). However, in practice these sequences of events may not happen, as some students may attempt the test the before the task or not perform the test at all. Others may think that the tests are good for revision and hence are to be attempted at the end of the semester. Others may choose to do neither tasks nor tests and only attempt the assignments. In any case, no attempt is made to enforce rules on how to use the system as students are free to use it in the way they think fit or not use the system at all. Another important point is that the system is not used for graded assessment purposes. It is designed as a learning system to help students to take control of their learning and self-assess their progress.

Wherever appropriate, each task is accompanied by a short test consisting of five multiple-choice questions. Students are allowed to re-attempt the tests as many times as they wish. To that end, when students complete a test, they are provided with immediate feedback (as shown in Figure 1). The feedback informs students why their selected answer is correct or incorrect. That is, the feedback does not give away the correct answer when students have selected an incorrect response. This provides value in students re-attempting the tests.

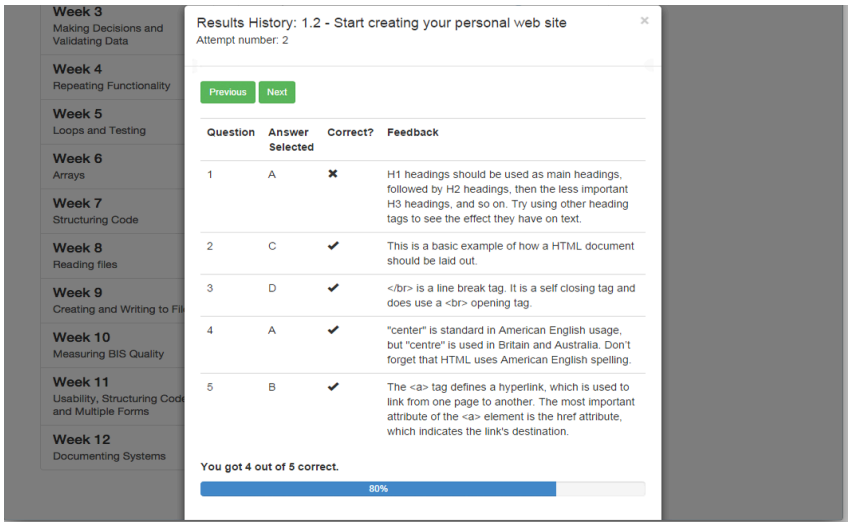


Figure 1: Feedback provided by TTM system

TTM also provides students with feedback regarding their performance. For example, students are shown result graphs of their last five attempts for each test they undertake, graphs displaying their highest scores for each week of the semester, graphs showing their highest scores for each test, and progress bars indicating overall progress in each TTM course they are undertaking.

There is no prescribed manner on how to use the TTM system. Thus, its simplicity is advantageous as it allows for flexible usage. Instructors are able to integrate TTM into their teaching approach as best suits them.

4 EVALUATION

The proposed teaching approach and technology-based supporting systems were trialled in three information systems (IS) courses. These included two technical courses that focus on programming applications for business purposes. The first course is an introductory information systems development course while the second is its successor. These two courses are typically taken in the first and second years of study respectively. The third course is on the development of e-business systems and although it contains a technical element (development of web-based systems), it is primarily focused on the business aspects of information systems. This course is typically taken in the second year of study.

Each of these courses is delivered as a one-hour lecture and a two-hour tutorial per week. The existing materials for these three information systems courses were significantly re-worked to fit into the teaching approach. This required the existing tutorial materials to be reviewed and divided into smaller bite-sized tasks that were scaffolded on top of each other and were made testable (through multiple-choice tests).

During the tutorials, students were given access to the TTM system, which would provide them with their tasks and tests. Students were told that they could re-attempt the tests, which carried no graded assessment marks, as many times as they wished. In these information systems courses, the tutors consulted students individually every few weeks. The consultation typically involved the tutors reviewing the student's performance in the TTM system, which recorded their number of attempts and scores for each test.

The teaching approach and its supporting web-based system was used for the entire 12 weeks of the semester for each of the three courses. Due to time restrictions, students were asked to volunteer to participate in the research at the end of week 7 (after it was deemed that they had gained enough familiarity and experience with the approach and system to make useful contributions to the research).

4.1 Experimental Design

The basis for evaluating the usefulness of the approach was a retrospective pre-test (RPT), also known as the "then test" (Howard, 1980). Retrospective pre-tests have been used instead of traditional pre- and post-tests to examine intervention outcomes as they can control some issues associated with pre- and post-tests approaches. These issues include (Nimon et al. 2010; Pelfrey 2009): (a) understanding of the question or statement prior to being identified in an intervention (also referred to as sensitisation effects), (b) exaggerated self-rating of ability prior to intervention (also referred to as response shift bias), and (c) requiring respondents of the pre-test to also participate in the post-test.

Conducting a pre-test prior to the approach being implemented relies on the availability of the same students to complete the post-test afterwards. This necessity is avoided through the single administration of the questionnaire in a retrospective pre-test format. Subsequently, it is recommended that retrospective pre-tests be used for examination of subjective experiences of program-related change (Hill & Betz 2005).

The retrospective pre-test is administered after an intervention has been put in place. Participants are asked to respond to each question/statement in the survey, as they perceived the response prior to the intervention. Participants then respond to the same question/statement, as they perceived the response after the intervention. This is commonly achieved through two Likert scales with one scale representing the pre-intervention responses and the other representing the post-intervention responses.

To answer the questions in the questionnaire accurately, students must understand the question and its context in relation to feedback received through their education. Through this questionnaire, students are asked to compare their feedback experiences between the TTM course they are undertaking and previous non-TTM courses they have completed. When not exposed to an alternative form of feedback, students become accustomed to the feedback they receive from most courses. Because of this, students may rate the feedback they receive from non-TTM courses higher than expected. This is commonly referred to a response shift bias. Once students have experienced TTM, they are exposed to an alternative feedback

(whether they find this an improvement or not) and can compare this to the usual feedback they are accustomed to.

4.2 Questionnaire Survey

Research participants completed a questionnaire survey, which focused on their perception of the quality, quantity and timeliness of feedback they received. Parts of the questionnaire survey used a retrospective pre-test as a mechanism for students to compare their experience with the new teaching approach against approaches used in their previous courses.

The questionnaire survey used was composed of four sections. The first section enquired about demographic details while the second section contained questions about students' preferences for different types of feedback (e.g., verbal, written, etc.). The third section focused on students' perceptions of feedback using the TTM approach and the fourth section focused on how TTM affected students' learning.

The third section of the questionnaire used a retrospective pre-test format. Thus, students were asked to answer each questionnaire item twice: once for courses which they have undertaken that did not use TTM and once more for the TTM-based course which they were currently undertaking. This allowed us to determine the difference between what students thought of non-TTM and TTM-based courses. The items for this section of the survey were adapted from their original source (Rowe & Wood 2008) into a retrospective pre-test format. The items enquired about students' feedback experiences in non-TTM and TTM-based courses and a sample of the questions are shown in Figure 2.

Please circle the option that best indicates how much you agree with the following statements in similar courses **THAT DID NOT USE TTM** and **THE COURSE THAT USED TTM**.

SD=Strongly Disagree **D**=Disagree **N**=Neutral **A**= Agree **SA**=Strongly Agree

	NON-TTM COURSES					TTM COURSE				
Written feedback is often difficult to read or poorly explained	SD	D	N	A	SA	SD	D	N	A	SA
I can discuss & clarify the feedback with my lecturer/tutor	SD	D	N	A	SA	SD	D	N	A	SA
Comparison against the rest of the class is helpful	SD	D	N	A	SA	SD	D	N	A	SA
Personal feedback is better than generic feedback	SD	D	N	A	SA	SD	D	N	A	SA
Written feedback is unreliable because the assessor can be subjective	SD	D	N	A	SA	SD	D	N	A	SA
The grade/mark is more important to my learning than the feedback	SD	D	N	A	SA	SD	D	N	A	SA
I like it when I am guided to work out the answers myself	SD	D	N	A	SA	SD	D	N	A	SA

Figure 2: Retrospective pre-test questions

4.3 Data Collection

A pilot study was conducted with selected tutors and students enrolled in the courses where TTM was used and 10 questionnaires were completed and helped to reword a few ambiguous questions.

Paper copies where distributed to students during week seven of the semester, after it was deemed that students had enough exposure and experience with the TTM learning approach. Of the cohort of 142 students from the three courses, 65 returned completed questionnaire surveys. Although two of the returned questionnaires had some missing responses, they were still useful as part of the analysis. The

sample of 65 participants was found to be fairly representative of the population in terms of gender, age group, mode of study, and student type (refer to **Error! Reference source not found.**).

Characteristics	Population		Sample	
	Count	%	Count	%
Gender				
Male	114	80%	37	57%
Female	28	20%	20	31%
No Response	0	0%	8	12%
Age Group				
18 – 21			47	72%
22 – 28			17	26%
No response			1	2%
Mode of Study				
Full time	137	96%	59	91%
Part time	5	4%	5	8%
No response			1	2%
Student Type				
Local	105	74%	44	68%
International	37	26%	20	30%
No response			1	2%

Table 1: Demographics of surveyed students

5 RESULTS AND DISCUSSION

Evaluation of the effects of the feedback provided by the learning approach is based on the analysis of questionnaire items related to each of the seven principles of feedback. The analysis for each item is based on two sets of data: one based on student responses about courses that they have previously undertaken which did not use TTM and another on the responses about the TTM-based course they have undertaken.

Studies have suggested that results from Likert scale format questions such as the ones used in the questionnaire survey should be analysed using the Wilcoxon Signed Rank Test (Alderman et al. 2003). The Wilcoxon Signed Rank Test was chosen as the most appropriate to compare two sets of results, not normally distributed, from the same participant on an ordinal or continuous scale by measuring the shift in mean between the two sets of data.

A common way to analyse RPT data is to compare the shift in the mean between the two sets of data. The mean is calculated by dividing the total score by the number of respondents. The score is the summation of weighed responses (no response = 0, strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5). The shift of the mean is the difference between the two means.

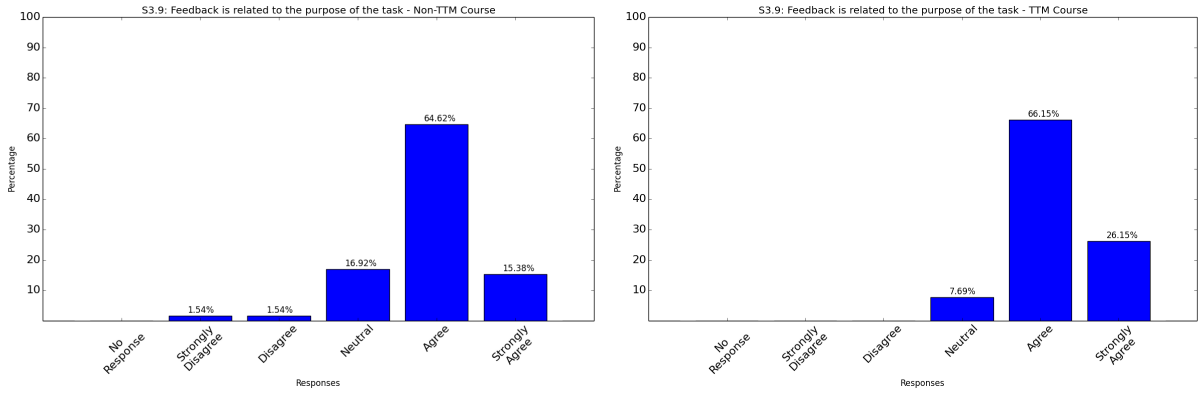
We also refer to the "total agreement" (sum of "agree" and "strongly agree"), "total disagreement" (sum of "disagree" and "strongly disagree"), and the shift between them in our discussions. Graphs of responses for courses that did not use TTM (referred to as "Non-TTM Course") and graphs of TTM-based courses (referred to as "TTM Course") are provided as visual aids to facilitate the discussion of results for the particular principle of feedback.

Since our focus in this paper, is the third principle of feedback, namely, deliver high quality feedback to students, we only present and discuss the results obtained for that particular principle of feedback.

A common approach to evaluating quality of feedback is to do so on three dimensions based on the 6 strategies for providing feedback: relevance, timeliness, and quantity. In our survey questionnaire, relevance of feedback is determined by two items: specificity of feedback, i.e., how related it is to the

purpose of the task (refer to Figure 3), and content quantity, i.e., if enough information is provided to make the feedback useful (refer to Figure 4).

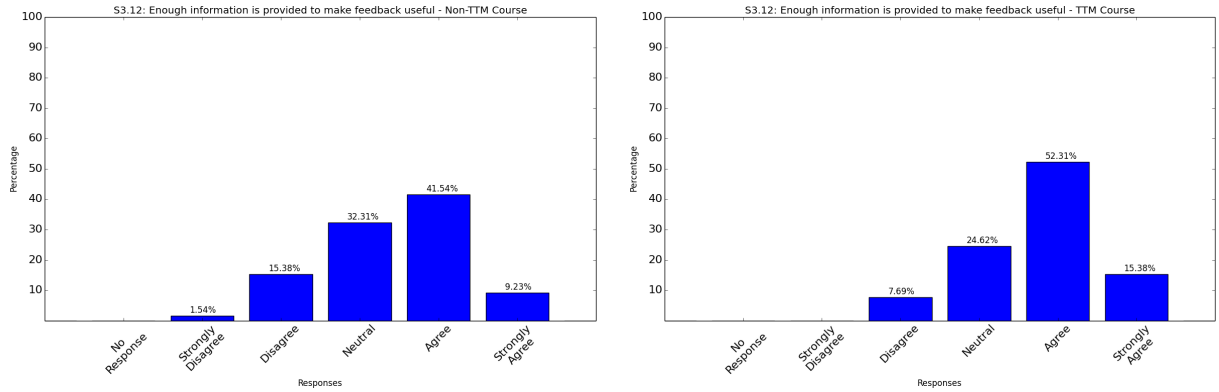
There is a positive shift in the mean of 0.27 in regard to the specificity of feedback in TTM courses (refer to Figure 3). There is a decrease of 3.08% (from 3.08% to 0.00%) in total disagreement and an increase of 12.31% (from 80.00% to 92.31%) in total agreement. Note that there are no disagreements with the specificity of feedback from TTM approaches. Thus, students find feedback from TTM to be very relevant to the purpose of their tasks.



(a) (b)

Figure 3. Specificity of TTM feedback to purpose of task.

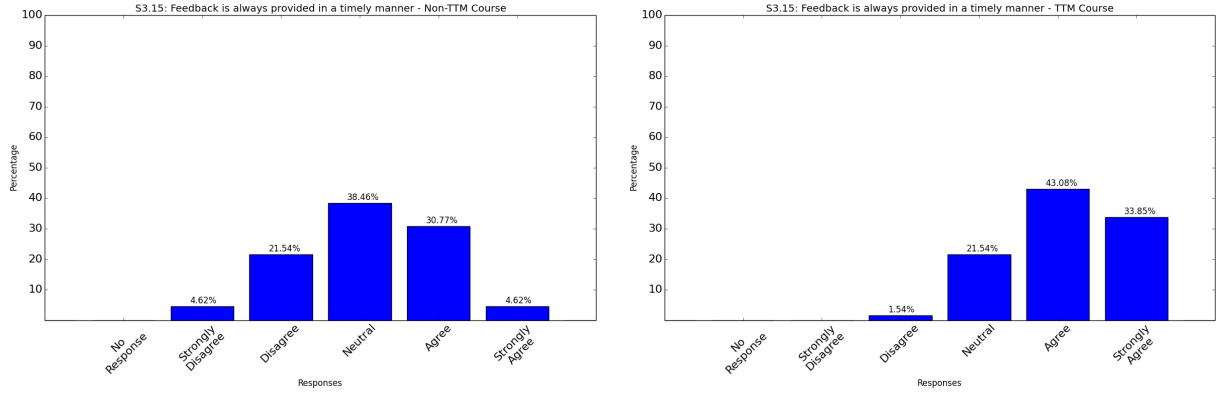
There is a positive shift in the mean of 0.33 in regard to feedback containing enough information to be useful (refer to Figure 4). There is a decrease of 9.23% (from 16.92% to 7.69) in total disagreement and an increase of 16.92% (from 50.77% to 67.69%) in total agreement. The largest individual shift is a 10.77% increase (from 41.54% to 52.31%) in agreement. These results indicate that students found that TTM feedback was better at providing an adequate amount of information to make the feedback useful.



(a) (b)

Figure 4. Content quantity of TTM feedback.

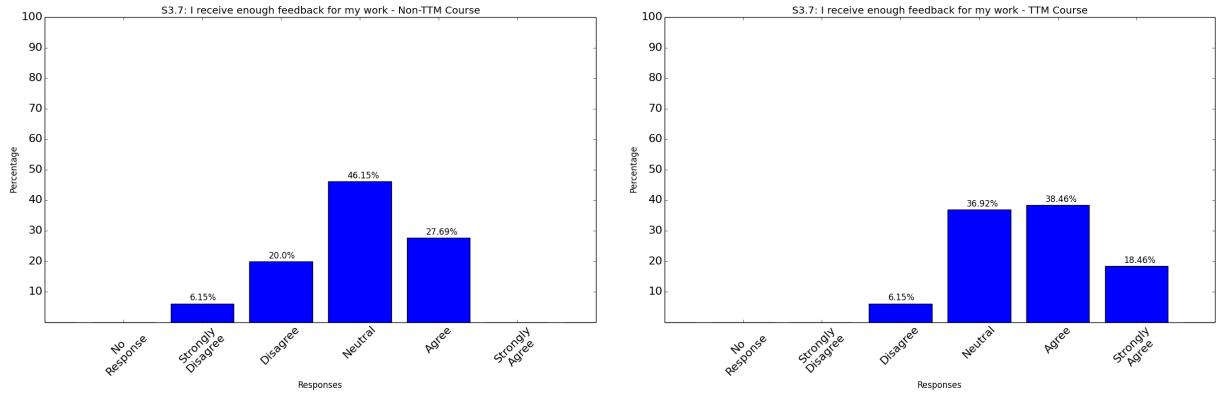
There is a large positive shift in the mean of 1.00 in the means of the timeliness of feedback data sets (refer to Figure 5). It is worth noting that students find the timeliness of feedback from non-TTM courses to be slow (a mean of 3.09). The total disagreement decreased by 24.62% (from 26.15% to 1.54%) and the total agreement increased by 41.54% (from 35.38% to 76.92%). The largest shifts are a 29.23% increase (from 4.62% to 33.85%) in strong agreement and a 20.00% decrease (from 21.54% to 1.54%) in disagreement. The results show that students found the feedback from TTM to be much more timely than from non-TTM courses. This is especially true as the feedback from TTM tests were provided immediately.



(a) (b)

Figure 5. Timeliness of TTM feedback.

There is also a large positive shift in the mean (0.74) in the quantity of feedback received by students (refer to Figure 6). It is also worth noting that students find the quantity of feedback from non-TTM courses to be low (a mean of 2.95). There is a decrease of 20.00% (from 26.15% to 6.15%) in total disagreement and an increase of 29.23% (from 27.69% to 56.92%) in total agreement. The largest individual shift is an 18.46% increase (from 0.00% to 18.46%) in strong agreement. Thus, TTM is a drastic improvement in providing adequate amounts of feedback to students. The strongest indicator of this is the increase in strong agreements: from none to 18.46%.



(a) (b)

Figure 6. Quantity of TTM feedback.

5.1 Implications for Pedagogy

The results of the study are positive as participants found that feedback from TTM-based courses is an improvement over courses that do not use TTM. In particular, timeliness of feedback was drastically improved, however, that was expected as TTM provides immediate feedback on test submissions. From our experience of using TTM and the results of the study, we recommend the following: (1) Particular care should be taken in how tests, and especially feedback for answer options, are devised; (2) The tests should strongly align with the tasks; (3) The feedback for incorrect answer options should provide students with information about why that option is incorrect and not give away the correct answer; (4) The feedback for correct answer options should explain why the answer is correct (in case the student guessed the answer). The graphs are also important aspects of feedback as they provide students with their improvement trends. Some instructors found it beneficial to use these to conduct brief reviews in class with students every few weeks.

The two main limitations of the work is that the TTM feedback is simple as the tests typically target the lower levels of Bloom's taxonomy (knowledge, comprehension, and application), and students were only exposed to TTM for seven weeks before completing the questionnaire. Further research should be conducted to determine how to best use TTM to address more complex tasks (higher levels of Bloom's hierarchy) and feedback. A longer-term study to investigate the effects of TTM over time would also be beneficial.

This work only addressed one principle of feedback (quality of feedback), albeit that was more complex (composed of a number of dimensions) compared to the other principles of feedback. However, future work should investigate if the TTM-approach positively affects the remaining six principles of feedback.

5.2 Implications for Research

This research is an initial attempt to improve the quality of feedback using a scalable (i.e, automated provision of detailed and specific feedback) technology-based approach. The participants reported that the quality of feedback from TTM-based courses was an improvement over other courses. However, it should be noted that the results are self-reported. Further research should be conducted to verify this both quantitatively and qualitatively. For example, the TTM log data could be analysed and compared against the self-reported data to verify the results to a greater level of accuracy. Also, qualitative interviews could be conducted to increase a depth of understanding in the effects of the TTM system.

6 CONCLUSION

Our objective was to develop a technology-supported learning approach for providing high quality feedback to students to improve their learning. The learning approach was designed based on sound pedagogical concepts and feedback principles and a web-based supporting system was implemented. The approach was trialled in three undergraduate IS-related courses and evaluated using a retrospective pre-test on several dimensions of feedback. In this study, we only report our findings that are related to the third principle of feedback, that is, delivering high quality information to students about their learning. The results show that this particular implementation of the learning approach was an improvement on traditional approaches as students found the feedback to be relevant, adequate and timely. Although, the current work is a preliminary attempt to address contemporary issues regarding feedback, it did achieve promising results, despite the simplicity and depth of the feedback provided to students. Future work should investigate providing more complex feedback to guide students through tasks designed to achieve higher-order skills on the Bloom's taxonomy of learning skills.

Although TTM was used in IS-related courses, it was designed to be non-discipline-specific. Thus, it should be experimented with non-IS-related courses to determine if it really is suitable for other disciplines. For example, TTM could be used to help students better understand a case study rather than the hands-on approach of developing an information system.

Although not feasible during the course of this research, in the future, a crossover experiment could be conducted in which half of the students are exposed to the TTM system for only half of the semester. The other half of the students in this time, complete the same work without the implementation of TTM. At the halfway point, the two halves could then swap exposing them to the alternative approach.

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