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Students' Perceptions of the Effectiveness of Assessment Feedback as a Learning Tool in an Introductory Problem-solving Course

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Students' Perceptions of the Effectiveness of Assessment Feedback as a Learning Tool in an Introductory Problem-solving Course

Abstract

There have been calls in the literature for reforms to assessment to enhance student learning (Shepard, 2000). In many instances, this refers to the need to move from traditional assessment procedures that are characterized as content-heavy, summative, and norm-referenced approaches to more constructivist and student-centred approaches, often characterized as more "... flexible, integrative, contextualized, process oriented, criteria referenced and formative" (Ellery, 2008, p. 421). Whereas summative assessment techniques rarely allow students to act on the feedback provided, formative feedback provided throughout the learning process can be used to improve future work and promote learning (Ellery, 2008; Higgins, Hartley & Skelton, 2002) by providing students an opportunity to learn from mistakes.

Allowing students to learn from their mistakes makes good pedagogical sense. To date there has been little research examining students' use of feedback (Higgins, Hartley, and Skelton, 2002). In an effort to begin to add to the literature in this area, this paper describes a study that explored the effectiveness of oral and written formative feedback when students were provided the opportunity to use it. The paper begins by reviewing literature related to assessment and how assessment relates to feedback in general. It then presents what the research has found in relation to students' perspectives of effective feedback and how they use it. The paper ends by presenting the results and discussion.

La documentation fait état de demandes de réforme de l'évaluation pour améliorer l'apprentissage des étudiants (Shepard, 2000). Dans plusieurs cas, cela traduit le besoin de passer des procédures d'évaluation traditionnelles caractérisées par la lourdeur de leur contenu, par leur aspect sommatif et par leurs approches normatives à des approches plus constructivistes et centrées sur les étudiants, souvent qualifiées de plus « ... souples, intégratives, contextualisées, axées sur les processus, balisées par des critères et formatives » (Ellery, 2008, p. 421). Alors que les techniques d'évaluation sommative permettent rarement aux étudiants de se conformer à la rétroaction fournie, la rétroaction formative tout au long du processus d'apprentissage peut être utilisée pour améliorer les travaux futurs et favoriser l'apprentissage (Ellery, 2008; Higgins, Hartley et Skelton, 2002) en donnant l'occasion aux étudiants d'apprendre de leurs erreurs.

Sur le plan pédagogique, permettre aux étudiants d'apprendre de leurs erreurs a du sens. À ce jour, il y a eu peu de recherche sur l'utilisation que font les étudiants de la rétroaction (Higgins, Hartley et Skelton, 2002). Le présent article se veut un ajout à la documentation dans ce domaine. Ses auteurs décrivent une étude qui porte sur l'efficacité de la rétroaction formative orale et écrite lorsque les étudiants ont eu l'occasion de l'utiliser subséquemment. Les auteurs commencent par une analyse de la documentation sur l'évaluation et sur les liens généraux entre cette dernière et la rétroaction. Ils présentent ensuite les résultats de recherche liée aux perspectives des étudiants sur la rétroaction efficace et sur l'utilisation qu'ils en font. Enfin, ils terminent par une présentation des résultats et par une discussion.

Keywords

consistent and transparent grading practices, multi-channel feedback, content of increasing complexity

Cover Page Footnote

Lynn Randall, Faculty of Education, University of New Brunswick; Pierre Zundel, Renaissance College, University of New Brunswick. Pierre Zundel is now President and Vice-Chancellor at the University of Sudbury, Sudbury, Ontario. Correspondence concerning this article should be addressed to Lynn Randall, Faculty of Education, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick, E3B 5A3. Email: lrandall@unb.ca.

Sadler (2005) summarized the arguments found in the literature for using criteria-based assessments. One of Sadler's arguments for the use of criteria-based feedback is based on fairness: "students deserve to be graded on the basis of the quality of their work alone, ... and without regard to each student's previous level of performance" and "students deserve to know the criteria by which judgements will be made about the quality of their work" (p. 178).

Sadler (2005) also noted a wide range of practice with respect to the use of criteria-based assessments in both theory and practice at the post-secondary level. Based on this review of the literature, he supported the practice of "specifying qualitative criteria for student responses..." (p. 185) because there is transparency in the grading process when reviewing (grading) student's work and such practice provides them with a resource to form and evaluate their work.

Although for many students and instructors, assessment is synonymous with grading, it is in fact a complex and multi-faceted practice (Fenwick & Parsons, 2009). Alverno College Faculty (1994) present a helpful framework for student assessment which breaks the process down into the following components: 1) defining explicitly observable criteria for effective performance (this involves both a description of what behaviours are sought and of the expected level of quality with which they might be demonstrated in a particular context); 2) creating a stimulus that elicits a performance (e.g., a task or assignment); 3) observing that performance to characterize it in terms of the criteria; 4) judging the quality of the performance relative to the criteria; 5) sharing results of that judgment with the person performing, using the language of the criteria; and 6) providing advice to help the person improve subsequent performances. The suggestions of Sadler (2005), Ellery (2008), and Higgins, Hartley, and Skelton (2002) fit well within Alverno College's framework.

A key component of student-centred assessment is feedback, but in their review of the literature, Black and Wiliam (1998) point out that various definitions of "feedback" exist. Black and Wiliam's (1998) definition is "...any information that is provided to the performer of any action about that performance" (p. 37). Further, the source can be internal or external, it can be compared against a reference standard or can be evaluated on its own terms (not against an explicit standard). Ramprasad (1983) defined feedback for use in management theory as information that is used to close the gap between actual performance and the reference level. According to Ramprasad, if the information is not used to alter performance it should be labelled as information or variance, rather than feedback. Applying Ramprasad's work to education, Ellery (2008) stated that, "...real learning takes place when feedback is used in ways that help close the gap between where students are ('actual level') and where they need to be ('reference level')" (p. 422). According to Ellery, the process of establishing the size of the gap between the actual and reference performance level is through assessment. Assessment generates both a judgment about the gap and formative feedback about the elements of performance that need to be changed to close it. These activities are represented in steps five and six of the general assessment framework outlined above (Alverno College Faculty, 1994).

Higgins, Hartley and Skelton (2001) have stated that "feedback does not realize its full potential to become an integral part of the learning process" (p. 207) and suggested the reason for this may be a result of poor communication between the instructor and the student. To overcome this problem, they put forth the notion of "feeding forward" information to students prior to beginning an assignment rather than "feeding back" after the assignment has been completed. Providing students with the criteria upon which they will be assessed before they actually begin writing the assignment is an example of feeding forward. This work is consistent with Ellery (2008), since it focuses on closing the gap between actual and desired student

performance. It also embodies Step 1 of the Alverno College framework that focuses on defining explicitly observable criteria for effective performance.

What is Effective Feedback?

From a student's perspective, feedback is one of the most useful products of assessment. Gibbs and Simpson (2003) argue that assessment supports student learning when: (a) it sets high standards; (b) causes students to engage in sustained and productive work; (c) arrives in time to be used to guide further study; (d) is intelligible to students, and (e) focuses on the work rather than the students themselves. Higgins, Hartley, and Skelton (2002) explored university students' understanding of instructor feedback. Students indicated the importance of timely, specific, and clear feedback from instructors. Comments that directly related to the assignment were found to be most helpful as opposed to general feedback provided to the entire class. Other research that has explored students' feedback preferences has found that students preferred feedback comments that

- were directed toward the task as opposed to the self (Black & Wiliam, 1998; Orsmond, Merry, & Reiling, 2005);
- addressed both the strengths and weaknesses of the work, that explained mistakes, and provided advice about how to improve their arguments (Black & Wiliam, 1998; Lizzo & Wilson, 2008);
- provided advice on how to improve their critical analysis (Lizzo & Wilson, 2008);
- helped them "focus on skills relating to a deep approach to learning" (Higgins et al., 2002, p. 61; McDowell, Smailes, Sambell, Sambell & Wakeline, 2007) and
- would help them on future assignments, and was fair (described as student friendly, legible, consistent and non-contradictory) (Lizzo & Wilson, 2008).

How Students Use Feedback

Considering that students at the tertiary level read and pay attention to instructor comments it is clear that the provision of feedback is necessary for student learning (Higgins et al., 2002). Orsmond et al. (2005) found students use feedback in various ways: (a) as motivation to work harder in order to improve understanding of the content thus increasing the likelihood of achieving better grades; (b) to talk with the instructor about their work; (c) increase learning about how to improve future work; (d) to reflect on their work and, in some cases, approach it from a different perspective; (e) to clarify their understanding of their performance as it relates to the grades they received, and; (f) to focus on instructors'/assignment expectations, especially when feedback is provided before a subsequent assignment.

Assessment for Learning

Literature in the field of assessment has identified characteristics of effective feedback and preferred feedback (from the students' perspective). Recent research (Gibbs & Simpson, 2004; Hattie & Timperley, 2007; Price, Handley, Millar, & O'Donovan, 2010) has commented on the varying roles of assessment and feedback, noting, for example, that assessment is too often used as a measurement tool or for grade justification rather than for learning purposes. Such notions are directly tied to Ramprasad's (1983) definition of feedback being used to close a performance gap, Ellery's (2008) notion of real learning, and Hattie and Timperley's (2007) notions of feed forward information (feedback provided must address future work).

Price, Handley, Millar, and O'Donovan (2010) noted the difficulty in attempting to measure the effectiveness of feedback. They began to explore students' engagement with feedback by interviewing a select group of 15 university students and 20 university professors. One of the purposes of their work was to explore the students' and professors perspectives on the effectiveness of the feedback they received/provided. Their findings echoed those found in earlier studies (e.g. be truly effective and to be considered feedback, students must have the opportunity to use the feedback to improve future performance) with the addition that students and professors differed in their perceptions of the use and quality of feedback and the students' desire for dialogue about the feedback. Biggs (1999) indicated that the combination of multi-channel feedback referenced to consistent assessment rubrics that are made available to students and repeated problems works synergistically to get students to focus attention on where they need to grow.

The literature has identified both characteristics of effective feedback and those that students say they prefer. Consistent with this body of research, and taking into account the idea that students must be provided opportunities to use the feedback provided, a course was intentionally designed that implemented characteristics the literature identified as contributing to student learning. More specifically, the feedback practices intentionally implemented included: (a) consistent and transparent assessment via the use of a rubric that contained explicit criteria directly related to grades; (b) the opportunity for students to use feedback provided on subsequent work; and (c) the use of multi-channel feedback (written, verbal, individual and group). This study set out to explore students' perspectives of the effectiveness of these three assessment practices.

Course Description

Students in this study were enrolled in the course *Mathematical and Economic Approaches to Problem-Solving*, a required component of the Bachelor of Philosophy in Interdisciplinary Leadership Studies offered at the University of New Brunswick in Canada. For more detailed information on the context and structure of the program in which this course was embedded, see Zundel and Mengel (2007). This particular course required students to solve four complex math problems using a structured problem-solving approach and economic reasoning. Each of the problems required students to build mathematical models on Microsoft Excel software to organize the quantitative information about the problem and compare the attractiveness of at least three solutions that could potentially meet the objectives. With the written description of the problem, students received an assessment rubric (see Appendix A) that contained a list of observable criteria such as "Identify constraints, objectives and resources."

These criteria were built on a conceptual model of structured problem-solving (Renaissance College, 2007) being introduced to the students for the first time in their program.

The course design was informed by elaboration theory (Reigeleuth & Stein, 1983). That is, the course involved engaging students in a series of similar activities of growing richness and complexity. The first of these is the “epitome,” representing the most basic form of the problem or activity that contains all the elements of the ability being developed. In subsequent attempts, students are given richer, more comprehensive or challenging examples of the same basic activity and “elaborate” their ability to work with it (Reigeleuth & Stein, 1983).

Although the nature of the problems changed substantially over the four attempts (see Table 1 for a description of the relevant features), the rubric used was consistent throughout. Students were required to demonstrate each of the assessment criteria twice to earn full grades and had four opportunities to do so. Given that one of the purposes of this study was to provide the opportunity for students to use feedback on subsequent work it should be noted that no letter or numeric grade was returned with the feedback sheets. Rather, for each problem, students received indications of which of the criteria associated with various course learning outcomes they had successfully demonstrated. In this way, students could focus on the feedback and not the grade. The potential percentage contribution to the overall course grade for each criterion demonstrated at least twice in four attempts was provided to students at the start of the course. The course grade was calculated only at the end of the course when students had exhausted all four attempts to demonstrate the criteria. The course and the underlying pedagogical approaches are described in more detail in Kuruganti and Zundel (2004).

Table 1
Description of Mathematical Problems

	Problem 1	Problem 2	Problem 3	Problem 4
Factors Describing Individual Assignments	Personal time, energy or financial budget.	Financial analysis of a simple investment project by a small firm.	Sustainability analysis.	Rewrite of one of problems 1-3. Done as take-home examination.
Information used to solve problem	Available to them directly from their personal or family records.	Most provided to them by instructor, selected items to be researched by groups.	Researched by students independently.	Depends on which problem rewritten.
Individual or Group	Individual	Group problem definition, individual analysis and report.	Group analysis, individual report and model building.	Individual report.
Conceptual Challenge	Understanding basic problem solving model and simple time, financial or energy calculations (e.g, amount per time).	Discounted cash flow analysis (time value of money), financial indicators, inflation, interest.	Social, environmental and economic sustainability, concept of a quantitative indicator, working with multiple indicators.	No new concepts introduced here.
Who Defines Topic Area of Problem?	Instructor	Instructor	Student with approval of instructor.	Depends on which problem rewritten.
Who Defines the Indicators Used to Assess Solutions to the Problem?	Instructor	Instructor	Students with help from instructor.	Depends on which problem rewritten.
Duration	5 weeks	4 weeks	4 weeks	2 weeks

Class time was also used to introduce key components of the problem solving, mathematical modelling, and economics theory content of the course. Students were provided opportunities to practice sub-components of the abilities being learned and assessed in the four class problems.

Students received multi-channel feedback as follows. First, each student received individualized written feedback from the course instructors based on the rubric provided with the

assignment. The feedback given to students after each assignment did not contain a letter or percentage grade. It included only a judgment of whether the attempt at demonstrating each criterion was successful and advice about how to improve on or repeat their performance (when successful). Second, students received individual feedback on the mathematical modelling performance from undergraduate teaching assistants who were primarily responsible for the assessment of spreadsheet models developed by the students. These teaching assistants were trained by the instructor to give feedback and themselves received instructor feedback about their feedback to students. Third, verbal feedback was provided to the whole class during a class lecture about common issues with their papers. The course instructors also provided weekly opportunities for individual or small group feedback during office hours.

Method

This qualitative study was carried out using two cohorts of students enrolled in a leadership program at the University of New Brunswick in Eastern Canada. Of the 49 potential participants, 24 were in their first year of university and were completing the course at the time of the study and 25 were second year students who had completed the course the previous year. All 49 students were contacted via email and told about the study and were invited to participate. From the 14 students who responded positively, we purposefully selected (Patton, 2002) participants that represented the cohorts of students enrolled in the program (both genders and both high school entrants and mature students). The participant population selected consisted initially of nine students, however one second-year interview was lost due to problems with the voice recording equipment. Thus the final sample included five first-year students (three males, two females) and three, second year students (one male, two females). Of the eight participants, six began university studies immediately following high school graduation, and two were mature students with some prior post-secondary education.

This research was reviewed by the UNB Research Ethics board. The interviewer reviewed the purpose of the study/interview with each participant and carried out the informed consent briefings ahead of each interview session. Following this initial informed consent discussion, the participant filled out the informed consent forms and gave them to the interviewer.

An independent experienced qualitative research interviewer with graduate-level research experience conducted all interviews. Prior to meeting with the participants, the researchers and interviewer developed an interview guide, the purpose of which was to provide some structure to the interview. As stated, the interview questions were meant to guide the discussion and the interviewer took the opportunity to ask probing questions where she felt they were warranted. The initial questions were intended to make the participant feel at ease and for the participant and interviewer to get comfortable with each other. For example, the interviewer first asked where the participants were from and then asked them to talk about how they heard about the program and why they decided to enrol in the program. Eventually the interview asked more specific questions, such as, "Describe your progression in mathematical modelling and structured problem solving in the math/econ course," and "What activities in your math/econ class are (were) most helpful to your improvement in problem solving and mathematical modelling?" All interviews were conducted in the College where students met for a number of classes. It was felt this was a familiar and comfortable space for students. Interviews lasted between one and one-half hours each. At the point when all eight interviews had been conducted, the interviewer

emailed the researchers stating she felt a saturation point had been reached. As a result, no supplementary interviews were conducted.

Data Analysis

All interview transcripts were audio-taped and transcribed. The constant comparative method of data analysis was employed (Glaser & Strauss, 1967). This method is used by researchers “who are not seeking to build substantive theory” (Merriam 1998, p. 159). Using this method, data analysis in the present study consisted of inductively derived category construction directly from the data and deductive categories based on constructs found in the literature. More specifically, the researchers conducted within case analysis followed by cross-case analysis. The process began with a line-by-line reading of a transcript in order to code the data. Here the researchers began identifying and naming segments of the data. Following the initial coding process, the researchers categorized the data segments by comparing and contrasting the various segments. The purpose here was to identify themes and patterns in the data. This process was repeated to (dis)confirm and add to previous thoughts and notes. Repeated readings occurred until no new codes and categories were added. This process was completed independently by both researchers. The researchers then met to discuss and compare their initial work. Through extensive discussion a master list of concepts derived from both researchers’ notes was created. This process was repeated with a second transcript; the purpose here was to look for similar concepts and categories and add new ones as they arose. The work from both interviews was compared and the work was merged into a master list of concepts and themes. Following this, the researchers used the master list to code a portion of another transcript to check for reliability of the coding. The inter-rater reliability was over 80%.

Data Trustworthiness

A number of steps were taken to ensure the credibility and trustworthiness (Patton, 2002) of the data. First, multiple cases were investigated. Second, transcripts were shared with participants to ensure that they represented participants’ thoughts. Participants had the opportunity to clarify or delete material. Third, the two authors conducted reliability checks to ensure the accuracy of coding.

Results

The results describe how participants experienced a course that intentionally incorporated the following three feedback practices: (a) consistent and transparent grading practices that were known prior to the assessment of work (via the use of a rubric); (b) the opportunity to use the feedback received on previous work in subsequent work; and (c) the provision of various types of feedback (written, verbal, individual, and group). Where appropriate, the intentional pedagogical practices employed will be used as the overall category title with sub-themes relating to each category discussed within each category. The two categories presented below relate to consistent and transparent grading practices and provision of multi-channel feedback. Each of these is divided into themes that group participant observations. The participants’ views are presented in each category/theme and the particular quotations have been selected because

they typify common perspectives found within each theme. To protect the identity of the participants, all names used are pseudonyms.

Consistent and Transparent Grading Practices

A rubric that described the abilities students were expected to demonstrate was provided in conjunction with the first assignment. The same rubric was used to grade each assignment. Written feedback was provided to students on their submitted assignments through the use of the rubric. Students found it extremely useful that the feedback indicated what they had done correctly, and it also provided guidance for where to improve their performance on the following assignments. Three themes emerged within this category.

Useful to guide future work. Participants repeatedly commented on the usefulness of the rubric. In particular, participants described how they used the rubric as a guide to assist them with their assignments. Joan stated, "... when I noticed that [there were] certain checkmarks [that] I ... failed to get the first time and the second time around I was like 'Okay this is what I need to concentrate on.' Paul stated, "... if I missed a checkmark on the first problem then on the second problem I ... made sure that ... I made a conscious effort to ... incorporate [it]..." When discussing how his papers improved from the first to second problem, John said, "I looked at my last paper and saw ... what I did and then how they said I could improve and then based the structure off of that." This must have been an important consideration to John as he referred to it again later in his interview when he said, "It just, it showed me what I did wrong and how I could fix it for the next problem and I understood what I did." As another example, Lisa offered the following comment:

I guess just because ... we followed that marking grid every time we had an assignment; we were like forced to do it. ... So ... if you [had] just been [told] ... "these are the concepts and you should use them while doing your [assignment]" I don't know if I really would have followed them as closely, so having to do that ... engrains it on your mind so that by the end of it you were just automatically using it and then you could write your paper and then look back at the grid and make sure you had everything, not use the grid to write the paper like I would have for the first [problem].

The opportunity for students to use the feedback acquired from previous problems to guide subsequent action was dependent on students knowing that subsequent problems would be assessed using the same rubric as previous ones and would provide further opportunities to demonstrate the same abilities.

Provided focus for follow-up conversations. When discussing the use of the rubric students repeatedly talked about how the written feedback helped them focus their attention on specific questions or issues they needed clarified. That is, students read the written feedback and then formulated questions for which they sought answers from the instructors during office hours. Rather than approaching the professor with broad questions, the students went seeking answers to specific questions. As Joan explained,

Like you'd get [written] feedback so if you didn't or you kind of [demonstrated concepts] Pierre would write, "okay, I kind of got the feeling ... [that you partially

understood] but perhaps a little bit more elaboration on what ...you mean[t] by this situation.” Which is great so you could look at your feedback and look where you needed to improve and then you could make up your questions or if you had any questions you could approach Pierre and [he would] point out where you[got] things wrong and [you could] ask questions.

Can’t ignore. The third theme to emerge was that students found this type of feedback could not be ignored. In response to the interviewer’s prompt about the use of the feedback provided on one his papers, Robert, whose answer was representative of all the students when asked a similar questions, stated, “For sure, you’d have to, to do well in the course.”

Deeper understanding and use of content. Five of eight participants also reported that the use of the same rubric for multiple similar problems provided opportunities to understand both the generic abilities (e.g., problem-solving) and the “content” of the problems (e.g., financial analysis concepts). Lisa explains,

I guess I just ... came to better understand the terms [in] the first problem; I thought I knew what I was talking about and I really didn’t and then I went to Pierre and got... more information and then [in] the lectures more information was given and I guess just throughout the term I came [to] better and better understand what the different terms and concepts entailed and like what I was expected to write about and... notice in the problem. So ... the understanding of what the terms meant and how to go about explaining them and being able to use math models to solve the problems [improved] because I struggled with that a lot on the first one but then once I had that as my example to refer back to I found it easier to figure out how to do the other two (Lisa).

The Provision of Multi-Channel Feedback

In addition to the rubric, two other forms of feedback were also given to students throughout the course. First, the professor provided general feedback to the entire class about issues that were of wide-spread concern when assignments were returned to students. Second, students had the opportunity to seek further individual verbal feedback by way of meetings with instructors during instructors’ set office hours. Related themes that came out during participant interviews were....

General verbal feedback provided in class. Following the grading of assignments, the instructors would use lecture time to review and discuss with the class the common issues that students appeared to do well with and struggle with. These discussions appeared to help students locate “where they were” in the course. For example, Paul said, “Well, after we got the assignments back Pierre and Mike always [went] over them and ...[pointed out] strong points, weak points, things everyone should consider for next time.”

Interview participants found it useful to listen to other students’ questions during the lectures where general comments were made about trends in student work on a particular assignment since it helped them clarify their own thinking. For example, Carla noted,

What would sometime happen that was really helpful was, the class would have a series of questions. That was really helpful because when somebody asked a

question I liked hearing the answer to their question and that was worthwhile. I think they were probably the most useful.

Personalized verbal feedback. Students had the opportunity to seek feedback through regularly scheduled office hours. When asked about the types of things students discussed during this time, they repeatedly referred to questions/topics that were directly related to the previous written feedback they had received on their assignments. The students sought personalized feedback. That is, they wanted information specifically related to what they did wrong and how they could have improved. The individualized nature of requested feedback was quite strong as demonstrated in the following two quotes:

I don't know, I guess just because he could tell me ...specifically what I had [to do.] [I'd ask] "well what else do I need?" kind of thing or what am I lacking? Because [with] the general explanations [provided]... you think you have it and you get your assignment back and you didn't get a checkmark for it and so just to know specifically what you left out or what you need to elaborate on more ...was more helpful than just the general gist of what you need to do (Lisa).

Talking to Pierre. Because his approach in terms of asking you questions would be like, "Okay let's look at this first, let's look at this now." Like that approach of looking at one thing at a time kind of helped me out in terms of "okay, this is what I need to do when I work it out" (Joan).

Discussion

This research set out to explore how students experienced a course that built in evidence-based practices that help students make effective use of feedback in their learning. The results demonstrate that students felt the positive effect of multi-channel feedback. In addition, the students' learning improved as a result of criterion-referenced grading (i.e., instructor comments on graded papers with the accompanying rubric, general comments provided in class with the opportunity to ask questions, and verbal comments during office hours). The eight students in this study all commented on the fact that they took advantage of more than one feedback practice. Further, their motivation to obtain this feedback was largely related to the opportunity and need to use the feedback in subsequent assignments.

One of the things we believe may be happening here that warrants further investigation is that a synergy developed between the use of a consistent rubric, the multiple channels through which students were provided feedback, and repeated opportunities to apply developing skills and knowledge. This is consistent with the findings of Biggs (1999) who reported synergistic effects of combining multi-channel feedback referenced to consistent assessment rubrics on student learning. In this study, we also found that patterns in criterion-referenced written feedback over several assignments helped focus students' questions during face-to-face contact with instructors. Students attended to feedback because they were confident that it would be useful to them in subsequent attempts (and possibly because they had no grades on which to focus). We have shown that that the students recognized an increase in their competency over the repeated attempts. This is consistent with the work of Alverno College Faculty (1994) who

characterized assessment *as* learning when explicit, behavioural criteria are used to provide feedback to students on their performance.

When the criteria used in the assessment rubric were derived from descriptions or decompositions of the complex abilities we hoped students would learn in the course, and when the repeated problems given to students provided opportunities to exercise them, a situation was created in which assessment became a key means of having students close the gap between their initial ability level and that desired. Without this explicitness in expectations, students in this study were hard pressed to know where to concentrate their efforts and how to learn from early failures. These findings are consistent with the framework proposed by Gibbs and Simpson (2003) who describe conditions in which assessment supports student learning. The authors identify the use of clear criteria that relate to the purpose of the assignment, coupled with prompt, detailed feedback using these criteria and opportunities for students to use it in subsequent assignments as key conditions for effective feedback. This is also consistent with the findings of Ellery (2008) and Higgins et al. (2002) who indicate that students can use formative feedback to learn from their mistakes.

Being provided the assessment rubric ahead of time was something new for students and needed substantial explanation during class time. Initially, they were not sure what to do with it or how it would be used. However, after the first paper had been returned and the rubric used, students found the rubric provided clarity and direction as they quickly understood where they needed to direct future efforts in order to demonstrate understanding of the concepts. It appeared that this feed forward information (Higgins et al., 2001) provided direction for students in a course that many students struggled with; the direction helped counter the effects of the difficult material.

We believe the rubric helped in another way: the students enrolled in the program of study were high achieving students (only 30 admitted per year to the degree program). These were students who had little experience struggling with content or having to ask for help. The rubric and the accompanying comments allowed some students to overcome the fear of asking for the help they needed from instructors.

Participants in this study clearly favoured the specific nature of feedback provided after each attempt, which is in keeping with previous research. However, the participants also found that the general feedback provided to the class about the assignments overall to be effective. This is likely due to the fact that the general feedback provided was more in line with Knight and Yorke's (2003) definition of general feedback, that being that the feedback was more structural in nature and directly related to expectations that were met and needed to be met for the next assignment.

Our results align well with four major prior research findings: first, Biggs' (1999) contention that aligned instruction (objectives, teaching, and assessment) is more likely to lead to deeper student learning; second, Paulaos and Mahony's (2007) finding on the importance of having criteria to complete the assignment and the assessment matching the criteria that had been previously provided; third, Orsmond, Merry, & Reiling's (2005) recommendation that "student progression and student feedback need to be more closely linked. Students want to have feedback regarding their coursework put into the wider dimension of their overall progression" (p. 382); finally, Price, Handley, Millar, & O'Donovan's (2010) finding that students want dialogue with instructors about the feedback provided.

Previous research has suggested that students use feedback in various ways; some students adhere closely to comments while others store them for future reference (Higgins et al.,

2002). This finding led researchers to suggest an exploration of *how* students use feedback as an area of future investigation (Higgins et al., 2002). Although this study did not set out to explore this question, our interview data provided some interesting insights relative to it. Students commented quite clearly that they had to use the feedback if they were to be successful on successive attempts. Because there was no grade to consider, students were more apt to closely examine and seek clarification of feedback on their work to guide and improve future efforts.

It should be noted that the multi-channel feedback and individualized criterion-referenced assessment described in this paper are resource intensive. That is, this course used a substantial amount of instructor (20-30 minutes per paper for four papers per student) and teaching assistant effort (six hours per week for ten weeks of the semester) for a modest number of students. In situations with fewer resources or greater numbers of students, the time required to provide individualized feedback would quickly become onerous. As a result, the choice of course learning objectives, the complexity and scale of assignments and assessment rubrics and the total number of assignments will need to be congruent with the instructional resources available.

Conclusion and Implications

We set out to explore how assessment practices and the students' perceptions of them affected their learning. During the interviews all eight participants talked about the practices and described how they felt each contributed to their learning. Although each practice was referred to individually, as well as in combination, by students, it became apparent to us that it was the combined effect of the practices that really impacted them. For example, students used the grading rubric as a guide to write their papers. That same rubric was used to provide detailed feedback to students on the extent to which they met the criteria. Knowing they would have another opportunity to demonstrate criteria not attained on one attempt, the students sought further clarification of how to overcome weaknesses through personalized one-on-one conversations with the professor.

The combined use of the pedagogical practices impacted students in three ways. First, they were motivated by the combined use of these practices to invest effort and attention in learning in areas where they needed growth, in spite of the very challenging nature of the subject matter. This motivation stemmed in part from the feedback they received, which identified both their strengths and areas for improvement, and from the further opportunities to demonstrate their growing skills that the subsequent problems provided. Second, the practices allowed students opportunities to focus their efforts on areas requiring growth, thereby helping them make good use of limited learning time. Finally, this focus by students on particular learning needs also led students to seek out (and the instructors to provide) specific instructional opportunities targeted to their needs, such as explanations of challenging concepts during instructor office hours.

In this paper we have focused on assignments and feedback mechanisms, but there are other structures that may play an important role in student learning. Based on our transcripts, two key areas for further investigation include: (a) the role of informal support networks (e.g., student peer groups) in maintaining student motivation and providing learning opportunities; and (b) the impact of not providing students actual grades on assignments on the level of attention paid to formative feedback.

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Appendix

RCLP 1052: Mathematical and economic approaches to problem-solving Problem 1 Grading Sheet

Student:

Outcome	Criterion Description	Adequate	Comments
Math Modelling (MM)	1. Calculate personal financial situation correctly		
	2. Make appropriate inferences about financial situation.		
	3. Spreadsheet model can be effectively used to carry out quantitative analysis on budget		
	4. Justified choice of variables for sensitivity analysis (SA)		
	5. Set reasonable range of values for SA		
	6. Made appropriate inferences from SA results		
Structured Problem-solving (PS)	1. Rephrase or describe problem accurately		
	2. Identify constraints, objectives and resources		
	3. Define key terms subject to ambiguity		
	4. Define at least 3 several possible strategies to improve financial situation		
	5. Predict performance of each strategy in terms of objectives and constraints		
	6. Select optimal strategy and justify choice		
	7. Identify assumptions and predict their effects on financial situation.		
	8. Observe own work accurately.		
	9. Analyse work with PS, MM and ML criteria		
	10. Judge quality of work accurately		
	11. Implement plan from last self-assessment.		

Working with quantitative information (multi-literacy - ML)	1. Use appropriate format to present information (table, type of graph or figure)		
	2. Labelling and caption is clear and effective		
	3. Appropriate use of quantitative information in report to support description and conclusions.		

Other comments: