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Multiple Submissions and their
Impact on the 'Path of Learning'

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Abstract

Learning theory from the 'behaviorist' camp suggests that quick feedback on a stimulus (problem) followed by repetition (resubmission) will increase student learning. To test this assumption an experiment was conducted. In an introductory management information system class students were given the opportunity to submit several skill-building project assignments prior to the due date. These submissions were graded promptly and feedback was provided. Students could then re-submit the project for final grading upon the actual due date. Data that were collected from a total of 159 students on three different database and spreadsheet skills indicate that there is a relationship between the choice of a student to take advantage of pre-grading and the grade on a subsequent test that assesses similar skills as in the project assignments. However, the relationship is not immediate, but it appears that students need to follow a 'path of learning' in order to achieve a higher level of understanding, whereby prompt and constructive feedback can play an important role.

Keywords: pedagogy, learning theory, feedback, computer literacy

1. INTRODUCTION

As introductory class sizes increase and more classes move to the web or a blended delivery method, building more learning options independent of the instructor are needed. Instructors have moved from the 'Sage on the Stage' to instructors who need to guide students to self-directed learning opportunities. (King, 1993; Jones, 1999).

A particular challenge for instructors of introductory computer literacy courses is to provide the appropriate level of hands-on skill assignments with clear feedback, followed by an opportunity for the students to learn from their errors. Unfortunately, students often only receive a grade and some minor comments as feedback, and no option is given to correct the errors and learn from them.

Learning theory suggests that increased learning will occur with additional stimuli and responses

(Gagne, Briggs and Wager, 1992). Even though there are several studies in pedagogy and psychology disciplines addressing this argument, they fail to address the validity of this theory in teaching skills.

This study investigates the results on 'learning' of providing students the opportunity to submit their assignments (database or spreadsheet) in advance of the due date (pre-grading). Students then received some high-level of feedback and were given the option to re-submit an updated assignment prior to the final due date. We expected that if students could 'correct' their errors before moving on to the next assignment or concept, learning from feedback would occur. In the current paper, we describe the experiment and its results, in an effort to address the following research question: **Does pre-grading followed by prompt feedback support student learning?**

In the following, we first provide an overview of the relevant literature on learning as a background to our study. We then describe the experiment, analyze and discuss the data that we collected, and draw conclusions.

2. BACKGROUND

Student success is influenced by the ability of the educator to present new information and to evaluate student understanding of the information. This process requires the student to learn the material covered by the educator.

Based on behavioral learning theory, Gagne et al. (1992) proposed several design principles for effective instructional courses, including contiguity, repetition, and feedback. Contiguity is the concept that the feedback should follow the response without delay. The longer the delay of the feedback to a learning stimulus, the less is the likelihood of correct answers to future similar questions. The second principle of repetition states that practice strengthens learning and improves a learner's retention. Gagne et al.'s (1992) conceptual framework of cognitive learning includes nine conditions for learning:

1. Gaining attention (reception)
2. Informing learners of the objective (expectancy)
3. Stimulating recall of prior learning (retrieval)
4. Presenting the stimulus (selective perception)
5. Providing learning guidance (semantic encoding)
6. Eliciting performance (responding)
7. Providing feedback (reinforcement)
8. Assessing performance (retrieval)
9. Enhancing retention and transfer (generalization)

The results of subsequent research studies suggest that responding (#6) and reinforcement (#7) are the events most directly connected to student success (Martin, Klein & Sullivan, 2007).

Murray (1998) encouraged a teaching style based on drill/rote learning and memorization, whereby modules should be built with many exercises that are example-driven. The principle of feedback requires that instructors inform the learner about whether an answer was correct or incorrect. In the case of an incorrect answer, feedback should include a new path to solve the problem. This new path could be a hint at the correct answer, a restatement of a prior fact, or even a new example that is less complicated (Uden and Beaumont, 2006). In addition, feedback to indicate that an answer is correct is suggested to be just as important as feedback on incorrect answers.

Orientation and recall is defined as a process where learning involves the synthesis of prior information that must be recalled to short-term memory (Uden and Beaumont, 2006). Similarly, there is a school of thought that learners construct knowledge by making sense of experiences in terms of what is already known (Eugenia, 2010).

In the framework of cognitive learning, responding is required from learners after they have been given sufficient material to comprehend an objective (Tomei, 2008). In particular when practice is included in a lesson, an *active* response to the material may be expected from the student. For example, following a database lesson, responding might require a student to create a query that will count the number of records in a table in order to demonstrate the comprehension of this newly introduced concept.

Given that responding can reinforce students' understanding, researchers have suggested that effective practice should parallel the assessments that are used to test the skills and

knowledge reflected in an objective (Reiser and Dick, 1996).

The current study builds on Gagne et al.'s (1992) framework. We focus on response and reinforcement as key learning components, as we investigate how hands-on skills could be taught more effectively. We trust that the knowledge gained from our study provides valuable insight for instructors, particularly those teaching online web-based courses.

3. EXPERIMENTAL DESIGN

For the experiment, we collected data in five sections of an introductory information systems course that included a number of computer literacy assignments and that were taught by two different instructors. Students were given the option to submit a number of skill-building assignments prior to the due date for pre-grading. Each assignment represented a new concept or advanced computer skill that was introduced in class prior to the assignment. Specifically, the following three skills provided the basis for our dataset:

1. Create a database with queries and multiple relationships between tables, using Microsoft **Access**;
2. Create a spreadsheet with multiple scenarios, using Microsoft Excel **Scenario Manager**;
3. Create a spreadsheet looking for an optimal solution, using Microsoft Excel **Solver**.

Following optional pre-grading and re-submission, a final grade for each project was assigned after the project due-date. The learned skills were then assessed with a hands-on portion of a comprehensive test that was given later in the semester. Figure 1 details the steps for each skill concept, whereby the shaded areas and bold text refer to data points that we recorded for the current study.

For the research model (Figure 2), we use the grade on the hands-on test as the main dependent variable and representing the level of understanding that a student has achieved with respect to a certain skill at the end of the course module. While we did not administer an entry-level test to assess a student's initial level of knowledge, we assume that the grade in the hands-on test is a good indicator for the extent to which a student who completes the course

possesses the skills and knowledge that the course was intended to provide.
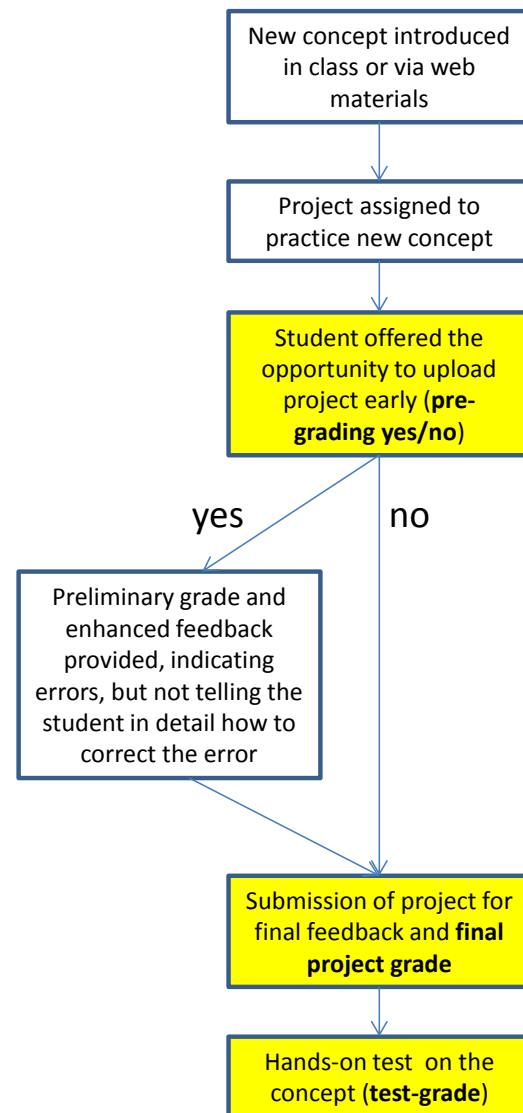
Figure 1: Teaching and Grading Process (Experiment setup)

In order to address our research question and to assess to what extent pre-grading can indeed enhance learning, and thus lead to a higher level of understanding, we wanted to find out whether there is a statistically significant link between pre-grading (yes/no) and the result of the hands-on test. In addition, we were also interested in the role of the final project grade as an intermediary step toward the hands-on test. Consequently, we analyze our data to test the following three hypotheses:

H1: Pre-grading (yes vs. no) is associated positively with the final project grade.
H2: The final project grade is associated positively with the grade in the hands-on test.
H3: Pre-grading (yes vs. no) is associated positively with the grade in the hands-on test.

In order to account for systematic differences between sections and instructors, we also include the instructor as a control variable in the model (Figure 2).
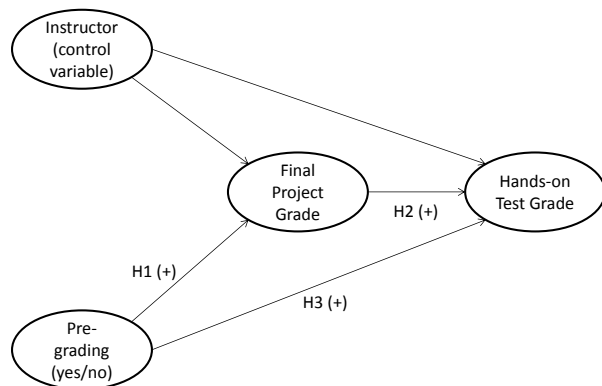
Figure 2: Research Model

4. DATA ANALYSIS

Data were collected from a total of 159 undergraduate students in an introductory information systems course, who were taught three computer literacy skills (Access, Scenario Manager, and Solver). The students represent a total of five sections in fall 2010 and spring 2011 that were taught by two instructors. One session was taught online, all other sessions were taught in the classroom. For each student, the collected data indicated (1) whether the student had taken the opportunity of pre-grading (yes/no) for a particular skill assignment; (2) the final project grade; and (3) the grade in the associated hands-on test.

To account for individual differences in teaching style, course structure, and details on projects, tests and grading schemes, we controlled for the instructor as a fourth variable in our analysis. The differences between the sessions of an individual instructor were not included in the analysis as these tend to be smaller than the differences between individual instructors (an assumption that was also confirmed by additional data analyses not reported here).

Each dataset pertained to a particular skill concept (Access, Scenario Manager and Solver), and was analyzed separately. After an initial review of the data we dropped records with grades of 0% or 1% for a project and/or hands-on test, because we assume that those results reflect a conscious choice of the students not to submit a particular assignment (e.g., after assessing their overall grade-related standing), rather than the level of student understanding. The resulting sizes of the three data samples were thus n=153, n=143, and n=144 for the Access, Scenario Manager and Solver skills respectively. Table 1 provides a descriptive summary of the data. Student participation in the pre-grading option ranged from 58% to 85%.

Table 1: Descriptive Statistics

Skill Concept sample size (n)		Access n=153	Scenario Manager n=143	Solver n=144
Pre-grading Yes		85%	58%	74%
Project Grade	Min	42.50	3.00	31.00
	Max	100.00	105.00	100.00
	Mean	93.94	84.28	92.06
	Std Dev	10.08	25.21	12.02
Test Grade	Min	73.00	2.00	8.00
	Max	100.00	100.00	100.00
	Mean	97.22	84.12	90.89
	Std Dev	4.46	21.92	12.72

Subsequent data analysis was performed using the structural equation modeling (SEM) approach with WarpPLS 2.0 software that applies the partial least squares (PLS) technique (http://www.scriptwarp.com/warppls). SEM is a second generation statistical method that, in contrast to regression, allows for the simultaneous assessment of multiple independent and dependent constructs, including multi-step paths (Gefen, Straub, and Boudreau, 2000). PLS was considered an appropriate method to test the research model because there is a broad agreement among scholars that PLS is well suited for exploratory research and theory development (in contrast to theory testing), which is the case in the current research study. Given that all of the variables in the research model included only one indicator, it was not necessary to assess the validity of latent variables. Instead, we could immediately proceed to test our hypotheses with the structural model.

As is indicated in Figures 3 to 5, we found comparable results for all of the three skill concepts of Access (Figure 3), Scenario Manager (Figure 4), and Solver (Figure 5). In all three datasets, H1 was confirmed at high levels of statistical significance, whereas H2 was confirmed at high to marginal levels of significance. Support for H3 was either marginal or non-significant. The instructor variable played a significant role in all three datasets. Even though the indicators of fit between the model and the data were acceptable to very good for all three datasets, some R square values, in particularly for the test grades were below 10%. Details follow:

Skill 1: Access

For the first dataset (Access) the model fit with the data was very good:

- Average Path Coefficient (APC)=0.165, P=< 0.001
- Average R-Squared (ARS)=0.126, P=0.002
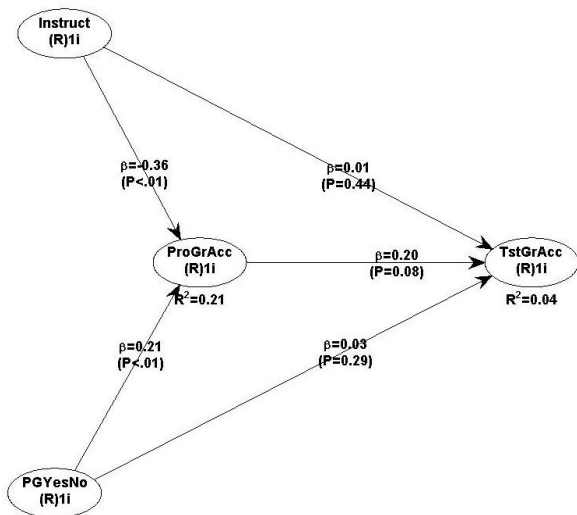- Average Variance Inflation Factor (AVIF) =1.091, Good if < 5

Figure 3: Results for Skill 1: Access

We found H1 to be supported with a significant path (p<.01) between grading and project grade. H2 was marginally supported with a path between project grade and test grade that is significant at p=0.08, and we also notice a low R square (0.04) for the test grade. It is the combination of the two paths (1) pre-grading/project grade, and (2) project grade/test grade that we refer to as the 'path of

learning' in the reminder of the paper. H3 was not supported for the Access skill. With respect to the control variable (instructor), we found the association between instructor and project grade to be significant below the 1%-level, whereas the association between instructor and test grade was non-significant (Figure 3).

Skill 2: Scenario Manager

For the second dataset (Scenario Manager), the model fit with the data was again very good:

- APC=0.213, P=<0.001
- ARS=0.130, P=<0.001
- AVIF=1.051, Good if < 5

We found H1 and H2 to be supported with paths that were statistically significant at or below 1% indicating support for the path of learning. H3 was supported marginally at the 6%-level of significance. In addition, we found both paths between instructor and project grade and between instructor and test grade to be significant at below 1% (Figure 4).
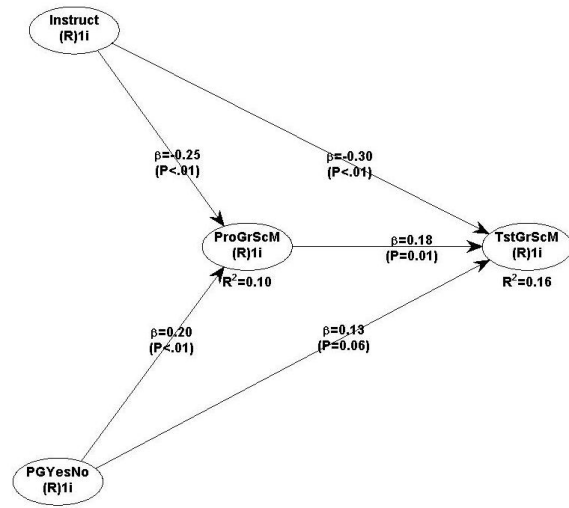

Figure 4: Results for Skill 2: Scenario Manager

Skill 3: Solver

For the third dataset (Solver) the indicators of model fit with the dataset were very good for two out of three indicators (APC and AVIF), but the ARS value was marginal:

- APC=0.165, P=<0.001
- ARS=0.095, P=0.102
- AVIF=1.045, Good if < 5

Again, we observed the path of learning in the form of strong support for H1 (p=0.01) and acceptable support for H2 (p=0.05), whereas H3 was not supported. And again, the association between instructor and project grade was significant at below the 1%-level of significance, whereas the association between instructor and test grade was not significant. As reflected in the marginal ARS, the R square values for both dependent variables were around 10% (Figure 5).
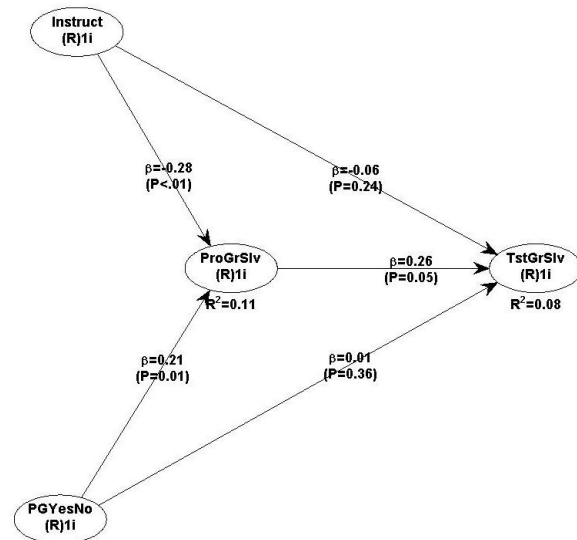

Figure 5: Results for Skill 3: Solver

5. DISCUSSION

In all three of our datasets, we found strong positive associations between pre-grading (yes vs. no) and final project grade (H1) and strong to acceptable support for the associations between final project grade and test grade (H2). The direct associations between pre-grading (yes vs. no) and the test grade were weaker if they were statistically significant at all (H3).

As a main outcome of our study, our data indicate considerable support for the 'path of learning' between pre-grading, project grade, and test grade independent of assignment and number of students who participated in pre-grading. It appears that the path of learning requires two steps and cannot be shortened: Students who submitted an assignment for pre-grading were as such not more (or less) likely to achieve a good grade in the hands-on test than students who did not take this opportunity (and vice versa). We suggest that students need to

take the feedback that is provided in the pre-grading comments serious, and that they subsequently have to make an effort to submit a high-quality project for a good final project score. It is this intermediate step of learning that – according to our data – is associated with higher grades in the concluding hands-on tests, thus, signaling higher levels of understanding and learning.

Several additional issues, however, warrant discussion. First, our results reflect a considerable amount of noise in the data, as indicated in the limited R square values, in particular for the hands-on test results. Although we do have statistical support for H1 and H2 that are supported by overall acceptable levels of model fit, there appears to be a need to examine additional variables for a deeper understanding of the domain.

For example, our data showed some highly significant associations between instructor and grades, in particular project grades. These associations most likely represent differences in grading practices but could also be an indicator of other factors, such as teaching effectiveness. At the beginning of the semester, the two instructors who participated in the experiment coordinated their skills assignments and hands-on tests to some degree to ensure structural comparability of the resulting data. Both instructors also used the same online system for grading (Matthews and Janicki, 2010). Despite these interactions, however, a number of differences remained, for example regarding the structure of the syllabus, individual teaching styles, project and test instructions, and grading rubrics. The format of delivery also varied as one of the five sections was taught online. To gain additional insights about the role of the instructor, an alternative analysis of the data was conducted where we measured the strength of moderated links between the instructors on the one hand, and the associations between pre-grading, project grades and test grades (H1-H3) on the other hand. The specific purpose of the alternative analysis was to find out whether the path of learning differed in strength between instructors, but the results of the analysis were not meaningful. Based on these mixed results, we suggest that it is necessary to examine in more detail the role of the instructor in future studies.

Another issue to consider is whether we are witnessing a situation where the smarter

students were the ones who primarily took advantage of the path of learning. The data show that the seemingly most difficult skill based on instructor experience and as measured by average grades (Scenario Manager), had the lowest percentage of students who submitted their projects for pre-grading (Table 1). Beyond this result, however, we did not have the opportunity to collect data on previous skills and the knowledge that students brought into the course, or on their overall grade level averages. We were surprised to find consistently significant associations between pre-grading (a choice made by the students) and the grades for projects and tests (H1 and H2). Given the limited statistical evidence that pre-grading alone resulted in high test scores (H3), we suggest our data to indicate that learning occurs along a pre-defined path, largely independent of a student's previous knowledge. While we cannot answer the question of whether smarter students benefitted more (or less) from pre-grading than students that were less smart, we found pre-grading to play an important role along the path of learning. We suggest that it may be up to the individual instructor to encourage all students in a class to take the opportunity for pre-grading (followed by efforts to submit a high-quality final project), given its critical role as part of the learning process.

6. CONCLUSIONS AND OUTLOOK

In the current paper, we set out to address the research question of whether pre-grading followed by prompt feedback can support student learning. Based on the data that we collected for three different skills that were part of an introductory information systems course taught by two different instructors, we suggest the following answer to our question: yes, pre-grading can support student learning, as long as a student takes the feedback from pre-grading seriously and makes an effort to subsequently submit a high-quality project.

Pre-grading alone does not seem to guarantee learning, as measured by hands-on test results, but pre-grading can help to increase the likelihood of a student submitting a high-quality project as part of the learning process. We suggest that our data provides evidence for a path of learning that includes three elements: (1) early submission of a project for pre-grading and prompt feedback; (2) preparation of a high quality project based on the early feedback for final project submission; (3) preparation for hands-on test based on feedback on the final project. Each step along the path is important to help a student learn and achieve a high level of understanding (test grade).

Before we conclude the paper, a couple of limitations and avenues for future research should be emphasized. As mentioned previously, our study is limited in its ability to determine exactly how much learning has occurred during the course, mainly because of the fact that skills were not assessed prior to the course. In addition, we could not fully explain the role of the instructor and also have no explanation for a considerable amount of noise in our data.

The former limitation means that we have not addressed in detail how learning actually occurs along the identified path of learning, and what factors may be particularly helpful in addition to pre-grading. While the focus of the current study was on the general role of pre-grading as part of the learning process, a better understanding of what actually happens along the path of learning should be considered an important extension of our work. In order to help instructors better structure their courses, it would be beneficial to have a deep understanding about what types of learners pre-grading can best support, as well as what groups of students are most prone to following the suggested path of learning. In this context, and as we discussed above, the role of the instructor and possibly other factors, need to be explored more deeply as well.

Another extension of our study could be to extend the path of learning to series of related assignments and projects. In some cases, more than one assignment might be given throughout a particular course module. It would be interesting to see to what extent the path of learning can be traced between assignments, which could again be helpful for course structuring and course management.

Lastly, it will be important to explore the boundary conditions of our findings and determine generalizability and applicability of the path of learning to other types of assignments, students and learning environments. While the results of our analysis were comparable across assignments and sections, and the path of learning was quite evident in the current study, the question remains, what factors in particular contributed to the similarity of the outcomes, and what factors

might have obscured or even obstructed the path of learning. Only if we understand not only the key aspects of the path of learning but also its limitations, can we truly move forward in our continued quest to help students learn.

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