Self-Reported Behaviors And Heuristic Beliefs About Learning and Preparing for Problem Solving Exams

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1.0 Introduction

In this paper, we describe a study of the self-reported behaviors and heuristic beliefs of students as they relate to solving homework problems and preparing for problem-solving exams. The purpose of the study is to develop an understanding of our students and to determine if our faculty's assessment of our students in this area is an accurate one. Often times, faculty members think, consciously or unconsciously, that students study and prepare for exams the same way we did and that the primary difference is in intellectual capacity, and this may cause us to teach in ways that do not lead to effective learning.

The first phase of the study was reported at the 2002 Frontiers in Education Conference by August, et al[1], where the self-reported learning behaviors and heuristic beliefs about learning of students in two technology classes as the Northeastern University were compared with the recommended best practices of the instructors of the course. They pointed out that people develop habits of learning from their experiences through a trial and error learning process, citing Lindsay and Norman[2], who say that "perhaps the most powerful description of the controlling factor of behavior is the Law of Effect: An action that leads to a desirable outcome is likely to be repeated in similar circumstances." They also mention the discussions on differences in learning styles have become quite common in engineering education circles, and these styles also reflect trusted habits of learning. Combining the concept of The Law of Effect and the notion of differences in learning styles has helped us to understand that students may have different beliefs about how learning takes place and different habits of learning.

Several related papers have been published recently on helping students modify their study habits in order to improve learning, such as Wright et al.[3] who described how students used journals to help them modify their study habits. Landis and Prather[4] described a process for changing students behaviors and attitudes in order to promote success among first-year engineering students. Landis[5] described behaviors of successful students, basing his approach on the published works of Tinto[6], Noel-Levitz[7], and Astin[8], and Mack et al.[9] talked about helping freshman focus on behaviors that promote success and achievement in engineering.

In this paper, we will present the results of an expansion of the Northeastern University study, this time conducted at Indiana University-Purdue University Indianapolis, where the survey of students and faculty was expanded to include the following:

- Students in a sophomore level course in analog electronics were asked to report their learning

behaviors and heuristic beliefs as of the start of the semester and at a point in the semester after three exams had been given through a multiple choice survey form, which is shown in Appendix A.
- Using the same survey items, faculty members in the Department of Electrical and Computer Engineering were asked to recommend what they considered were best practices and to predict the predominant choice of the students.

Information collected in this study would be useful to faculty members and to students in several ways:

- It will help faculty understand their students from the point of view of how they are trying to learn. This information would be useful in the development of a retention program.
- It will help students understand what faculty considers ideal learning behaviors and how faculty members evaluate them learners.

2.0 Background

August, et al [1] presented the results of six of the fourteen survey items that demonstrated striking differences between student responses and instructor best-practice responses. The full survey (14 items) and data are shown in Appendix A. The items covered four different areas of habits and beliefs, including the following:

- Reading the textbook and published notes
- Solving homework problems
- Preparing for problem solving exams

The six items where students' responses differed strikingly from the course instructors' best-practice recommendations focused on the following questions:

- Do students read the textbook assignment prior to the lecture or wait until after the lecture to read it?
- When do students begin working on homework assignments—as soon as it is assigned or just before it is due?
- Do students put off working on homework if they know it won't be collected?
- Do students have all of the homework problems solved when it is time to begin reviewing for the exam?
- If an exam is to be made difficult, do students prefer the difficulty to be due to having an excessive number of basic problems (requiring speed) or a few difficult ones (requiring deep thinking)?
- Do students practice extra problems, or do they study only the assigned problems?

Since the publication of [1], the research team collected and analyzed data for the purpose of

determining if there is a relationship between students' responses to the survey items and their performance on exam problems of increasing levels of difficulty. The results of this part of the Northeastern University project were presented at the 2002 Frontiers in Education Conference but not published in the proceedings. The results of the study may be obtaining by contacting yokomoto@iupui.edu.

3.0 The Current Study

For the current study, the authors used a subset of the items from Northeastern University study, selecting only those items that showed a marked difference between student responses and instructor recommendation for best practice. The investigation was expanded to assessing students' self-reported behaviors and heuristic beliefs at the start of the semester and at a point in the semester after three exams had been given. In addition, the faculty members in the department were surveyed, and they were asked to indicate their best-practice recommendations and their prediction of the predominant student response. In addition, data from three problem-solving exams was collected in a sophomore course in analog electronics. However, unlike the Northeastern University study, the analysis of the performance on the problem solving exams did not take into consideration the degree of difficulty of the individual problems.

A statistical analysis using SPSS was conducted, investigating the statistical significant differences between the following:

- The students' self-reported behaviors and heuristic beliefs at the start of the semester and at a point in the semester after which three exams had been completed to determine if students changed their behaviors during the course of the semester.
- The faculty members' best-practice recommendations and their actual expectations to determine if faculty impressions of students of student behaviors were commensurate with their best-practice recommendations.
- The student responses after three exams and the faculty predictions of how students would respond to determine if faculty expectations were similar to students' reported behaviors.

3.1 Student Responses After Three Exams Compared with the Start of the Semester

First, we present the findings of our assessment of habits of learning of twenty-three sophomore students in an analog electronics course in the Department of Electrical and Computer Engineering. They were administered a survey instrument after taking the third exam, slightly past mid-semester. They were asked to respond at that point in time and to respond as they would have at the beginning of the semester. The distributions of the student responses are shown in the six following tables. For example, for item 1, 21.7% of the students chose response (a) as their pattern of behavior at the start of the semester, 43.5% chose response (b), and 34.8% chose response (c).

Using the marginal homogeneity test for significance, an extension of the McNemar test and tests

for changes using the chi-square distribution for testing before and after designs, none of the items demonstrated a significant change in responses between the start of the semester and after the third exam. However, the authors would like to point out that even if the change is not significant, the distributions in themselves are interesting because they demonstrate differences in learning patterns that faculty members might want to address in order to improve retention and learning.

1. When I start to work on homework problems, I usually

	Start of the Semester	After Three Exams
a. Start by reviewing the textbook or the instructor's printed notes.	21.7%	26.1%
b. Start by reviewing notes I took in class.	43.5%	52.2%
c. Try to solve them without doing either.	34.8%	21.7%
The change is not statistically significant.		

2. When I have a homework assignment that consists of solving a set of assigned problems that have to be turned in, I usually.

	Start of the Semester	After Three Exams
a. Start solving them more than a day ahead of when they are due.	59.1%	39.1%
b. Start solving them the night before they are due.	22.7%	43.5%
c Start solving them during the day they are due.	18.2%	17.4%
d. Don't have anything to submit them when they are due.	0%	0%
The change is not statistically significant.		

3. When I have a homework assignment that consists of solving a set of assigned problems that will not be collected, I usually

	Start of the Semester	After Three Exams
a. Start solving them more than a day ahead of when they are due.	13.0%	17.4%
b. Start solving them the day before they are due.	43.5%	39.1%
c Start solving them during the day they are due.	17.4%	17.4%
d. Still have to solve some of them when it comes time to study for the exam.	26.1%	26.1%
The change is not statistically significant.		

While the change in the distributions is not statistically significant, the data shows that students wait longer to start working on homework when it is not collected, to the point that 26% say that they still have to solve some of the problems when it is time to start reviewing for exams.

4. When it is time to start studying for an exam, I usually

	Start of the Semester	After Three Exams
a. Have all of the homework problems solved	65.2%	60.9%
b. Still need to solve some of the homework problems.	30.4%	34.8%
c. Sometimes have to take the test without having solved all of the homework problems.	4.3%	4.3%
The change is not statistically significant.		

It is interesting to note that about one-third of the class still needs to solve some of the homework problems when it is time to start reviewing for the exam and approximately 4% sometimes take the exam without having solved all of the homework problems.

5. If a test has to be made difficult, I would rather have the difficulty come from

	Start of the Semester	After Three Exams
a. Having to solve so many basic problems that I barely have enough time t complete the exam (speed test).	43.5%	39.1%
b. Having to solve fewer problems, including some that require a lot of deep thinking that I barely have enough time to complete the exam (thinking test).	56.5%	60.9%
The change is not statistically significant.		

The data shows that there is a difference in cognitive style, with substantial proportions preferring a speed test (a) and thinking test (b).

6. When practicing problem solving for a problem solving exam, I usually

	Start of the Semester	After Three Exams
a. Try to solve extra problems that were not assigned.	43.5%	69.6%
b. Review only the solutions of assigned problems.	56.5%	30.4%
The change is not statistically significant.		

While the change was not significantly, the indication is that students in this particular class, the proportion of students who solved extra problems by the third exam increased by 26.1 percentage points.

3.2 Responses of the ECE Faculty

Thirteen faculty members in the ECE Department were asked to respond in two ways also, first with their best-practice recommendations, shown under the column heading, "Ideal Behavior," and second with their prediction of the predominant responses of the students, shown under "What Students Will Say." Their results are shown below. The marginal homogeneity test was used again to determine if any of the changes in the distributions were statistically significant. As

you might imagine, all but item 1 demonstrated statistically significant differences in the distributions.

1. When students start to work on homework problems, they should

	Faculty Selection of Ideal Behavior	Faculty Prediction of What Students Will Say
a. Start by reviewing the textbook or the instructor's printed notes.	50.0%	33.3%
b. Start by reviewing notes I took in class.	33.3%	33.3%
c. Try to solve them without doing either.	16.7%	33.3%
The change is not statistically significant.		

2. When students have a homework assignment that consists of solving a set of assigned problems that have to be turned in, they should

	Faculty Selection of Ideal Behavior	Faculty Prediction of What Students Will Say
a. Start solving them more than a day ahead of when they are due.	100%	23.1%
b. Start solving them the night before they are due.	0%	76.9%
c Start solving them during the day they are due.	0%	0%
d. Don't have anything to submit them when they are due.	0%	0%
The difference between the recommended ideal behavior and that faculty predicted that students would say is statistically ($p < .05$).		

3. When students have a homework assignment that consists of solving a set of assigned problems that will not be collected, they should

	Faculty Selection of Ideal Behavior	Faculty Prediction of What Students Will Say
a. Start solving them more than a day ahead of when they are due.	92.3%	0%
b. Start solving them the day before they are due.	7.7%	15.4%
c Start solving them during the day they are due.	0%	23.1%
d. Still have to solve some of them when it comes time to study for the exam.	0%	61.5%
The difference between the recommended ideal behavior and that faculty predicted that students would say is statistically ($p < .05$).		

4. When it is time to start studying for an exam, students usually

	Faculty Selection of Ideal Behavior	Faculty Prediction of What Students Will Say
a. Have all of the homework problems solved	91.7%	16.7%
b. Still need to solve some of the homework problems.	8.3%	50%
c. Sometimes have to take the test without having solved all of the homework problems.	0%	33.3%
The difference between the recommended ideal behavior and that faculty predicted that students would say is statistically ($p < .05$).		

5. If a test has to be made difficult, students would rather have the difficulty come from

	Faculty Selection of Ideal Behavior	Faculty Prediction of What Students Will Say
a. Having to solve so many basic problems that I barely have enough time t complete the exam (speed test).	0%	76.9%%
b. Having to solve fewer problems, including some that require a lot of deep thinking that I barely have enough time to complete the exam (thinking test).	100%	23.1%
The difference between the recommended ideal behavior and that faculty predicted that students would say is statistically ($p < .05$).		

6. When practicing problem solving for a problem-solving exam, students should

	Faculty Selection of Ideal Behavior	Faculty Prediction of What Students Will Say
a. Try to solve extra problems that were not assigned.	100%	15.4%
c. Review only the solutions of assigned problems.	0%	84.6%
The difference between the recommended ideal behavior and that faculty predicted that students would say is statistically ($p < .05$).		

3.2.1. Comments on the Faculty Responses

The fact that the faculty selection of ideal behaviors was statistically different from their prediction of student responses is not unreasonable. Students are probably too constrained by demands on their time to do the ideal, even if they were aware of the ideal. It is even debatable whether or not faculty members acted in the ideal way when they were undergraduate students.

3.3 Comparing Faculty Predictions With What Students Said After Three Exams

In order to simplify the presentation of the comparison of faculty responses with student responses, we will limit our discussion to how faculty predicted students would respond ("Faculty Predictions of What Students Will Say") with student responses after the third exam ("What Students Said After Three Exams").

1. When students/I start to work on homework problems, they/I usually

	Faculty Prediction of What Students Will Say	**What Students Said After Three Exams**
a. Start by reviewing the textbook or the instructor's printed notes.	33.3%	26.1%
b. Start by reviewing notes I took in class.	33.3%	52.2%
c. Try to solve them without doing either.	33.3%	21.7%
The change is not statistically significant.		

2. When I have a homework assignment that consists of solving a set of assigned problems that have to be turned in, I usually.

	Faculty Prediction of What Students Will Say	**What Students Said After Three Exams**
a. Start solving them more than a day ahead of when they are due.	23.1%	39.1%
b. Start solving them the night before they are due.	76.9%	43.5%
c Start solving them during the day they are due.	0%	17.4%
d. Don't have anything to submit them when they are due.	0%	0%
The change is not statistically significant.		

Faculty should take note that 17% of the students did not start solving the homework assignments until the day they are due, even if they are to be turned in.

3. When I have a homework assignment that consists of solving a set of assigned problems that will not be collected, I usually

	Faculty Prediction of What Students Will Say	What Students Said After Three Exams
a. Start solving them more than a day ahead of when they are due.	0%	17.4%
b. Start solving them the day before they are due.	15.4%	39.1%
c Start solving them during the day they are due.	23.1%	17.4%
d. Still have to solve some of them when it comes time to study for the exam.	61.5%	26.1%
The change is not statistically significant.		

Even through the difference in patters was not significant, it is interesting to note that faculty underestimated the work ethic of students when assigned problems are not collected. For example, whereas only 26.1% of the students said that they still have to solve some of the homework problems when it is time to review for an exam, 61.5% of the faculty predicted students would say the same.

4. When it is time to start studying for an exam, I

	Faculty Prediction of What Students Will Say	What Students Said After Three Exams
a. Usually have all of the homework problems solved	16.7%%	60.9%
b. Still need to solve some of the homework problems.	50.0%%	34.8%
c. Sometimes have to take the test without having solved all of the homework problems.	33.3%	4.3%
Faculty predictions of what students will say differed significantly from what students said after three exams ($p < .05$)		

As with item 3 above, faculty underestimated the student work ethic with regard to solving homework problems. Whereas 60.9% of students said that they usually have all of the homework problems solved when it is time to start studying for an exam, only 16.7% of the faculty predicted that students would say the same. We expected the results to be in the opposite direction.

5. If a test has to be made difficult, I would rather have the difficulty come from

	Faculty Prediction of What Students Will Say	What Students Said After Three Exams
a. Having to solve so many basic problems that I barely have enough time t complete the exam (speed test).	76.9%	39.1%
b. Having to solve fewer problems, including some that require a lot of deep thinking that I barely have enough time to complete the exam (thinking test).	23.1%	60.9%
Faculty predictions of what students will say differed significantly from what students said after three exams ($p < .05$)		

A large majority of the faculty (76.9%) predicted that students would prefer a speed exam, while only 39.1% of the students said the same.

6. When practicing problem solving for a problem solving exam, I usually

	Faculty Prediction of What Students Will Say	What Students Said After Three Exams
a. Try to solve extra problems that were not assigned.	15.4%	69.6%
d. Review only the solutions of assigned problems.	84.6%	30.4%
Faculty predictions of what students will say differed significantly from what students said after three exams ($p < .05$)		

Note that faculty members are inclined to believe (84.6%) that students review only the solutions to assigned problems, while students said (69.6%) that they try to solve extra problems that were not assigned.

4.0 Applications of the Results of the Study

The results of this study can be used in several ways in faculty discussions on student learning and in student workshops on improving learning. For example, instructors can use the data to open discussion in class or in out-of-class special session (the latter is a better choice) in order to inform students of the "smarter" choices and how students can compensate if they are unable to switch from a less-than-smart choice to a smarter choice. Alternately, engineering programs may choose to conduct across-the-curriculum workshops for all students on how to improve learning, using the results of this study to inform students.

Here are some suggestions for ways that the different kinds of data can be used:

- The data in section 3.1, which reports the distributions of student responses for each item, will demonstrate to faculty that students are diverse in their learning behaviors and heuristic beliefs about learning. The data in section 3.2, which reports on the distributions of faculty responses for each item,

particularly their prediction of what students will say, can serve as a starting point in a discussion on department expectations for students and student learning and retention.

- The data in section 3.3, which reports on the difference between faculty predictions of what students will say and what students said after three exams, can also be useful in discussions on student learning and retention.
- The survey instrument itself, with all of the options for each item, can be used in a student workshop on improving learning. Unsuccessful students who have habits that are inappropriate may not be aware of the behaviors and beliefs of successful students.

5.0 Concluding Remarks

In this paper, we presented the results of an assessment of students' self-reported learning behaviors and heuristic beliefs about learning on activities such as doing homework and preparing for exams. The instrument is shown in Appendix A. The items pertained to study behaviors and heuristic beliefs about learning. Students were asked to select choices that described their behaviors and beliefs as of the third exam and at the start of the semester. Faculty input was also obtained by modifying the assessment instrument, asking them to recommend the ideal, best practice from among the choices and to predict how students would respond on the instrument. While the data in itself was informing, the authors also made three comparisons.

In Section 3.1, we compared the student responses as of the third exam with the responses that they would have made at the start of the semester. There were no significant differences between the two sets of data, indicating that the instrument did not detect any changes in their behaviors.

In Section 3.2, we compared what the faculty said was the ideal choice against what the faculty predicted that students would say on each item. As you would expect, five of six items (items 2-6) demonstrated a significant difference between the distributions of the ideal choices and the faculty predictions of what students would say.

In section 3.3, we compared the faculty predictions with what students said after the third exam. Three of the six items (items 4-6) demonstrated a significant difference between faculty predictions and students responses.

The particular items are not as important to the authors as the demonstration of distribution of responses of each group and the differences between both populations. Those who are interested in the particular differences may refer to Sections 3.1, 3.2, and 3.3. The importance of the demonstration of differences lies in their application to helping faculty and students improve teaching and learning, respectively.

6.0 Bibliography

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7.0 Biographies

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APPENDIX A--STUDENT SURVEY FORM

Instructions: Please consider your courses that have a lecture component where you are given reading assignments to read prior to attending class, where you solve homework problems, and where your grade in the course depends on your ability to solve calculations-based problems on written exams. If you course uses instructor-written course notes that he/she distributes, please interpret these to be the same as "textbook". There are two responses requested for each item in this section.

1. When I start to work on homework problems, I usually
   a. Start by reviewing the textbook.
   b. Start by reviewing my class notes.
   c. Try to solve them without looking at the book or my notes until I run into difficulties.

   My answer at this point in time (circle one): a b c
   My answer at the start of the semester (circle one): a b c

2. When I have a homework assignment that consists of solving a set of assigned problems that have to be turned in, I usually
   a. Start solving them more than a day ahead of when they are due.
   b. Start solving them the night before they are due.
   c. Start solving them during the day they are due.
   d. Don't even have anything to submit them when they are due.

   My answer at this point in time (circle one): a b c d
   My answer at the start of the semester (circle one): a b c d

3. When I have a homework assignment that consists of solving a set of assigned problems that will not be collected, I usually
   a. Start solving them more than a day ahead of when they are due.
   b. Start solving them the day before they are due.
   c. Start solving them just before class meets
   d. Still have to solve some of them when it comes time to study for the exam.

   My answer at this point in time (circle one): a b c d
   My answer at the start of the semester (circle one): a b c d

4. When it is time to start studying for an exam, I usually
   a. Have all of the homework problems solved
   b. Still need to solve some of the homework problems.
   c. Sometimes have to take the test without having solved all of the homework problems.

   My answer at this point in time (circle one): a b c
   My answer at the start of the semester (circle one): a b c

5. If a test has to be made difficult, I would rather have the difficulty come from
   a. Having to solve so many basic problems that I barely have enough time t complete the exam

(speed test)

b. Having to solve fewer problems, including some that require a lot of deep thinking that I barely have enough time to complete the exam (thinking test).

My answer at this point in time (circle one): a b
My answer at the start of the semester (circle one): a b

6. When practicing problem solving for a problem solving exam, I usually
   a. Try to solve extra problems that were not assigned.
   b. Review only the solutions of assigned problems.

My answer at this point in time (circle one): a b
My answer at the start of the semester (circle one): a b