Reflection and Evaluation Data from e-Learning Modules on Learning Styles and Motivation

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Abstract

Two e-learning modules on learning styles and motivation have been developed to help create independent lifelong learners. The modules have been administered to approximately 450 undergraduate mechanical engineering students over the past two years (since 2012). A total of 9,235 explanatory responses from the two modules have been coded and categorized. Analysis of these data indicates that the modules have been effective in teaching students about learning styles and factors of motivation. Additionally, the modules provide students with strategies for improving their learning. Feedback from students helped to identify improvements for a second version of the modules.

Introduction

Engineering graduates of today must be prepared for a lifetime of learning and adaptation. Thus, one of the goals of engineering education is to create independent, lifelong learners. This project is developing e-learning modules in support of that goal. The modules are designed to teach undergraduate engineering students about metacognition and motivation as well as strategies to improve learning. The first versions of the modules were tested in two mechanical engineering classes by hundreds of students. To test the effectiveness of this intervention, students also take a lifelong learning readiness survey, either before or after completing the modules. Analysis of the pre and post surveys shows some improvement in scores from pre to post. This is reported elsewhere[1]. The purpose of this paper is to analyze the data from the reflection and evaluation portions of each module. This information gives more specific information about the effects that the module has on students.

Description of Modules

The modules were designed such that module takers would experience different learning styles and levels of motivation. Both modules have the following sequence of activities:

- Complete an instrument (learning style inventory or motivation questionnaire)
- Go through a tutorial that gives a first hand experience of the influence of learning style or motivation
- Go through a tutorial about learning style or motivation strategies
- Respond to reflection questions
- Evaluate the module

Figure 1 describes the architecture of the learning styles module. It begins with a Barsch learning style inventory[2]. This module creates the "first hand experience" by asking students to learn material that is presented in different learning styles. It presents tutorials on mitosis and Punnett squares, with one presented in the most preferred style and one in the least preferred style. Students answer quiz questions before and after each tutorial. The biology tutorials are followed by a tutorial about learning styles and strategies targeted to each style. At the end of the module, students reflect on the experience and evaluate the module.
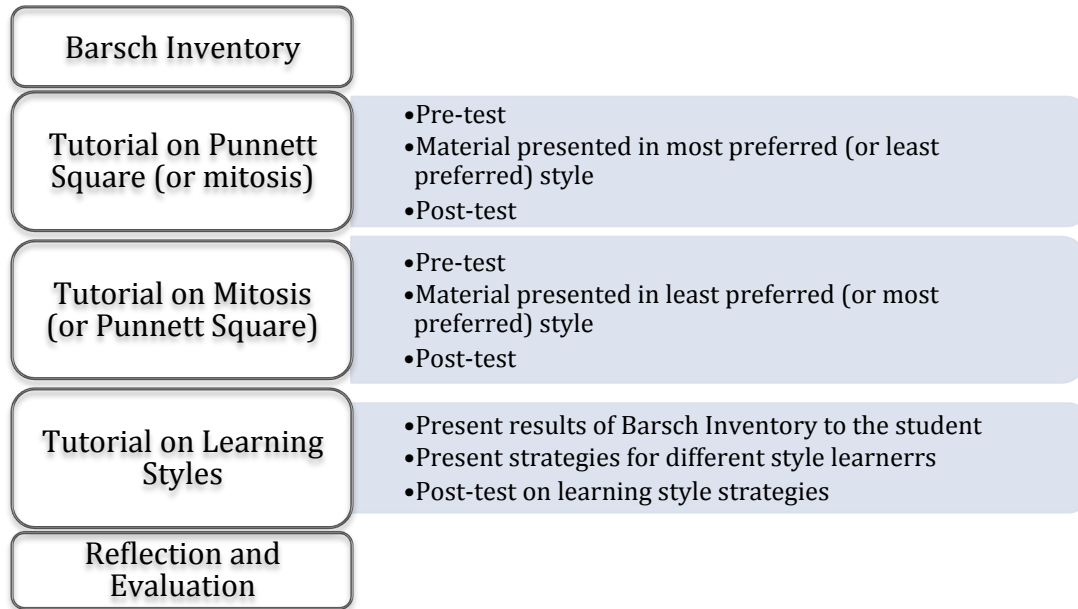
Barsch Inventory

Tutorial on Punnett Square (or mitosis)
- Pre-test
- Material presented in most preferred (or least preferred) style
- Post-test

Tutorial on Mitosis (or Punnett Square)
- Pre-test
- Material presented in least preferred (or most preferred) style
- Post-test

Tutorial on Learning Styles
- Present results of Barsch Inventory to the student
- Present strategies for different style learnerrs
- Post-test on learning style strategies

Reflection and Evaluation

Figure 1. Outline of learning styles module

Figure 2 describes the motivation module. It consists of an MSLQ[3] (motivated strategies for learning questionnaire) followed by three tutorial sections. The MSLQ assessment determines motivation across six factors: control beliefs, extrinsic motivation, intrinsic motivation, self-efficacy, task value, and test anxiety. Next, the module manipulates task value by exposing students to tutorials on northern lights and osmosis. Then, the module manipulates control beliefs by means of tutorials on aluminum can manufacturing and photosynthesis.
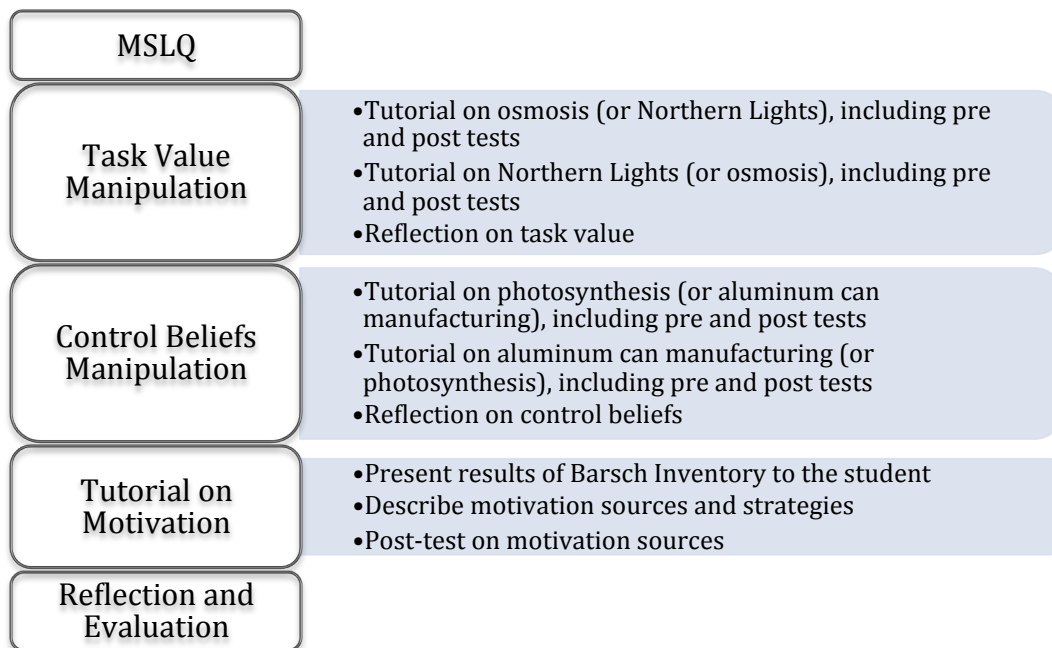
MSLQ

Task Value Manipulation
- Tutorial on osmosis (or Northern Lights), including pre and post tests
- Tutorial on Northern Lights (or osmosis), including pre and post tests
- Reflection on task value

Control Beliefs Manipulation
- Tutorial on photosynthesis (or aluminum can manufacturing), including pre and post tests
- Tutorial on aluminum can manufacturing (or photosynthesis), including pre and post tests
- Reflection on control beliefs

Tutorial on Motivation
- Present results of Barsch Inventory to the student
- Describe motivation sources and strategies
- Post-test on motivation sources

Reflection and Evaluation

Figure 2. Outline of motivation module

Analysis of Reflection and Evaluation Responses in the Learning Styles Module

We analyzed data from 449 participants (all mechanical engineering students) that took the learning styles module. The module asks nine closed-form questions. Table 1 presents the results of the closed-form questions. Students are generally satisfied with the module, but the results show room for improvement.

Table 1. Evaluation of learning styles module by 449 participants
(SA=Strongly Agree, A=Agree, N=Neutral, D=Disagree, SD=Strongly Disagree)

	SA	A	N	D	SD
1) I thought the module was easy to use	33%	46%	13%	6%	1%
2) I understand differences in learning styles after completing the module	22%	59%	13%	4%	1%
3) I enjoyed working with the module	10%	37%	33%	15%	4%
4) I was surprised to find out my most preferred style	6%	24%	38%	23%	8%
5) I was surprised to find out my least preferred style	3%	15%	40%	30%	11%
6) I think the listed strategies of my preferred learning style will help me become a better learner	11%	43%	32%	10%	3%
7) I will apply what I learned through completing this module to my learning in this class	7%	48%	31%	9%	4%
8) I will apply what I learned through completing this module to my learning in other classes	8%	52%	27%	7%	4%
	E	VG	G	F	P
9) Overall I would rate this module	7%	30%	44%	13%	4%

The module asks five open-ended style questions accepting explanatory responses:
1. I was surprised to find out my most preferred style –Please Explain
2. I was surprised to find out my least preferred style –Please Explain
3. What in particular do you think will be most helpful?
4. What would you suggest to improve this module?
5. Is there any part of this module you particularly liked or disliked?

A total of 2,245 explanatory entries were analyzed. Just 30% of students were surprised about their preferred style, and 18% of students were surprised about their least preferred style. In the open ended follow ups to the 1st and 2nd questions above, students indicated they became aware of their most and least preferred styles by means of trial and error, self-awareness, life experiences, or having taken a similar evaluation.

In response to the 3rd open-ended question about what would be most helpful from the module, students mentioned specific strategies from the module: frequent breaks while reading (for 25 minutes at a time) and studying, note-taking suggestions, and other kinesthetic, visual, tactile, and auditory strategies. Some students indicated they would continue using strategies already

developed because they already know about their preferred learning style; many indicated they have been using the suggested learning style strategies. A few students mentioned the module helped them to understand certain behaviors and preferences that they observed they possessed, such as not being able to understand lectures when only listening. Some students felt that simply being aware of their most and least preferred learning styles would benefit them.

From the responses to the 4th question, suggestions to improve the modules can be summarized as follows:

- Many students already knew about learning styles and had developed personal learning strategies–mostly similar to the ones presented in the module; a suggestion would be to administer the module earlier on in the academic year (fall) and earlier in the curriculum (first year).
- Shorten the module length.
- For the tutorials, replace the biology topics with more interesting or useful topics.
- Fix bugs that occurred with some browser/operating system combinations: "next" and "back" buttons that didn't work; Punnett squares flash animation that didn't work; module freezing.
- Provide a way to save progress so that the module does not have to be completed in one sitting.
- Provide more information about the module to help students understand the module objective.

Table 2 summarizes responses to the 5th question about student likes and dislikes. Many students liked the format of the module and found it easy to use; however, some experienced technical difficulties. As noted above, many of the students are aware of the information presented in the learning styles module as they approach the end of their undergraduate education. Finally, some students liked the biology topics while others did not.

Table 2. Summary of things students particularly liked and disliked in the learning styles module

Likes	Dislikes
Format of the module	Technical issues, module errors
Easy to use	Extensive reading
Information presented in module	Inability to review information (test scores, answers to questions)
Topics	Topics
Visuals, animation	Have seen information before

Analysis of Reflection and Evaluation Responses in the Motivation Module

The motivation module was completed by 467 participants. The module collects a significant amount of data from each participant. In addition to the MSLQ and quizzes, it includes 37 evaluation and reflection questions (most of these in the Evaluation and Reflection portion of the module and some sprinkled through earlier sections of the module). Fifteen of these questions

were of open-ended style and accepted explanatory responses; a total of 6,990 explanatory entries were analyzed.

Task Value Manipulation This section of the module presents tutorials on osmosis and Northern Lights. In addition to the pre and post-quizzes on these topics, students answer a set of attitudinal questions about each topic both before and after the tutorial. They also reflect on their most and least favorite courses. As this section manipulates task value, the module suggests, "You may notice different levels of motivation as you work through these."

As a check on whether the module really does manipulate task value, we ask for level of student agreement with the three statements shown in Tables 3 and 4. These tables show average responses for the Osmosis and Northern Lights tutorials, respectively. Note that the scores tend to increase slightly from before to after. This is only important in that it lets us know that the module material does not completely turn off students. It is more important to note that the scores for Northern Lights are much higher than for Osmosis. This confirms that we do achieve a difference in task value by the selection of these two topics. The difference is not significant for every student, and for a few, osmosis has the higher task value. A closer look at individual students will be important when looking at correlations with other module results.

Table 3. Averages of task value related responses before and after taking the Osmosis tutorial
(5 = Strongly Agree and 1 = Strongly Disagree)

	Average Before	**Average After**
I am very interested in osmosis	2.58	2.71
I think the material on osmosis is useful	2.60	2.97
I like the subject matter of osmosis	2.65	2.85

Table 4. Averages of task value related responses before and after taking the Northern Lights tutorial (5 = Strongly Agree and 1 = Strongly Disagree)

	Average Before	**Average After**
I am very interested in the Northern Lights	3.87	3.82
I think the material on the Northern Lights is useful	2.96	3.29
I like the subject matter of the Northern Lights	3.76	3.87

After the Osmosis and Northern Lights tutorials, the module asked the two questions shown in Table 5. This result connects student perception of task value with their motivation. The difference in task value has translated into a difference in motivation. As was our intention, most students are experiencing different levels of motivation.

Table 5. Comparison of motivation levels for the Osmosis and Northern Lights tutorials

	Osmosis	**Northern Lights**	**Same for Both**
Which topic were you more motivated to learn?	8%	77%	15%
For which topic did you make a greater effort to learn?	16%	54%	31%

Students were then asked a follow up question about why they made a greater effort to learn Osmosis or Northern Lights. Responses were categorized using the MSLQ categories. For example, those who indicated they made greater effort to learn a particular topic because it was useful or interesting were grouped together and coded under task value. Table 6 summarizes the responses. Task value ranks as the highest factor for the students that made a greater effort to learn Northern Lights and for those that made a greater effort to learn Osmosis.

Table 6. Summary of reasons students made a greater effort to learn one topic over the other

Motivation Factor	Northern Lights (351 students)	Osmosis (73 students)
Task Value	66%	40%
Intrinsic	15%	30%
Extrinsic	2%	1%
Self-Efficacy	6%	12%
Control Beliefs	0%	0%
Test Anxiety	0%	0%
Other	10%	16%

The results from Tables 3-6 provide evidence that the module is accomplishing the desired manipulation of task value and accompanying motivation level.

Control Beliefs Manipulation The tutorials on aluminum can manufacturing and photosynthesis were designed to manipulate control beliefs. The introduction to the aluminum can tutorial includes this statement: "The lesson on How Aluminum Cans are Made uses skills typically acquired by first and second year Mechanical Engineering students. This lesson is at an appropriate difficulty level and you should be able to succeed at this module given enough effort to learn the material." The photosynthesis introduction includes: "The lesson on Photosynthesis is typically more difficult for Mechanical Engineering students. Don't be concerned if this material is too difficult for you." In addition to pre and post-quizzes, there are questions about the student's belief in their own success and how it affected their effort and motivation to learn each topic.

At the conclusions of both the aluminum can and photosynthesis tutorials, the module asks the questions shown in Table 7. The results indicate that students have higher control beliefs about aluminum can manufacturing as was the intention.

Table 8 presents results about student motivation. Students did perceive a difference in motivation. However, only 35% thought that belief in success affected their motivation. Though we did not ask about interest, it is possible that task value also caused a difference in motivation for these tutorials.

Table 7. Average of student responses to questions about control beliefs (N=230)
(5 = Strongly Agree to 1 = Strongly Disagree)

	How aluminum cans are made	Photosynthesis
For the material on ___, I believe that if I study in appropriate ways, I will be able to learn this material	4.33	3.93
For the material on ___, if I am not able to understand the material, it is my own fault	3.96	3.69
For the material on ___, I believe that if I try hard enough, I would be able to learn this material	4.34	4.06
Did you believe you could succeed in the ___ lesson? (5=yes, 1=no)	4.51	4.03

Table 8. Summary of responses to questions about motivation in control beliefs section

	Yes	No	Other
Did you notice a difference in motivation for the aluminum cans lesson versus the photosynthesis module?	59%	41%	
Did your belief of success affect your effort or motivation to learn?	35%	49%	16%
In the photosynthesis section, were you motivated to prove us wrong in our saying that the amount of effort does not affect performance?	27%	65%	8%
If you did not believe you would succeed in the photosynthesis section, were you motivated to even try?	41%	29%	30%

Additional module questions gave more insight about student understanding of motivation. For example, there was this closed form question: *The module discussed six aspects of motivation. Consider your favorite course at Michigan Tech. Which of these aspects was/is most applicable to you in that course?* As shown in Table 9, students most often identified intrinsic motivation as the most relevant for their favorite course.

Subsequently, the module asks the respondent to explain their answer. We categorized the text responses according to the same six motivation factors. Table 10 summarizes the results. Note that the percentages do not match those in Table 9. Student explanations tended to identify task value as the most important factor. This finding indicates that students may not be learning the distinction between intrinsic motivation and task value.

Table 9. Closed-form responses about motivation factors applicable in favorite course

Task Value	22%
Intrinsic	45%
Extrinsic	13%
Control Beliefs	6%
Self-Efficacy	7%
Test Anxiety	6%

Table 10. Summary of responses to open-ended question about motivation factors
applicable in favorite course

Task Value	52%
Intrinsic	15%
Extrinsic	12%
Control Beliefs	3%
Self-Efficacy	2%
Test Anxiety	5%
Other	12%

Similarly, students were asked: *Consider your least favorite course at Michigan Tech. Which of these aspects was/is most applicable to you in that course?* As shown in Table 11, test anxiety, extrinsic motivation and task value are the most relevant factors. The analysis of the follow-up open-ended responses, in this case, showed a closer match to the closed-form responses (see Table 12).

Table 11. Summary of closed-form responses about motivation factors applicable
in least favorite course

Task Value	21%
Intrinsic	3%
Extrinsic	26%
Control Beliefs	5%
Self-Efficacy	9%
Test Anxiety	36%

Table 12. Summary of responses to open ended question about motivation factors
applicable in least favorite course

Task Value	26%
Intrinsic	1%
Extrinsic	24%
Control Beliefs	7%
Self-Efficacy	0%
Test Anxiety	23%
Other	20%

The motivation module concludes with closed and open-form evaluation questions. Table 13 summarizes the results of the closed form evaluation questions.

Table 13. Evaluation of motivation module (N=433-450)

	SA	A	N	D	SD
1) I thought the module was easy to use	15%	57%	18%	8%	2%
2) I understand the different aspects of motivation after completing the module	12%	67%	13%	7%	1%
3) I enjoyed working with the module	5%	37%	34%	19%	5%
4) I was surprised by my motivation scores	9%	38%	34%	16%	3%
5) I think the strategies for improving motivation will help me become a better learner	8%	56%	27%	7%	2%
6) I will apply what I learned through completing this module to my learning in this class	5%	52%	28%	12%	2%
7) I will apply what I learned through completing this module to my learning in other classes	5%	56%	27%	10%	2%
	E	VG	G	F	P
8) Overall I would rate this module	5%	24%	47%	19%	4%

Students also responded to the open-ended question: *What, in particular, do you think will be most helpful?* Table 14 summarizes the categorized responses.

Table 14. Summary of benefits students will take away from the motivation module

Awareness, knowledge, using strategies	14%
Increasing motivation	12%
Switch to Intrinsic	10%
Switch to Task Value	10%
Improve Test Anxiety	12%
Self-Efficacy	2%
Control Beliefs	4%
Moving away from Extrinsic	2%
Other	34%

In terms of improving the module, the most common suggestions were to reduce the length, improve the user interface and fix bugs, and make the content more interesting (new topics, more audio and visuals).

Improvements to Modules

Based on the student feedback, improvements were made and second versions of both modules have now been introduced and tested. The overall structures remain the same as in Figures 1 and 2. The learning styles module has adopted a different learning styles instrument (Felder-Silverman[4]). Both modules have new content to address student comments about the modules

being "boring." For example, in the learning styles module, nutrition and business topics replaced the biology topics.

In Fall 2014, 50 students tested the new learning styles module, and 49 students tested the new motivation module. Table 15 compares the results from the evaluation questions for the two versions of the learning styles module. The responses have been averaged using a 1 (Strongly Disagree) to 5 (Strongly Agree) scale. Overall, the scores have improved. The students are more surprised about their most and least preferred learning styles. This was the hoped for result when we switched the learning styles instrument. Also, the strategies in the second version are viewed as more useful. Despite the new topics, the enjoyment of the module remains an area for improvement. Student feedback will again be used to make further improvements.

Table 15. Comparison of student evaluations of two versions of the learning styles module
(Strongly Agree = 5, Strongly Disagree = 1)

	Avg V1	Avg V2
1) I thought the module was easy to use	4.0	3.8
2) I understand differences in learning styles after completing the module	3.9	4.0
3) I enjoyed working with the module	3.3	3.4
4) I was surprised to find out my most preferred style	2.9	3.2
5) I was surprised to find out my least preferred style	2.7	3.0
6) I think the listed strategies of my preferred learning style will help me become a better learner	3.7	4.0
7) I will apply what I learned through completing this module to my learning in my classes	3.4/3.5*	3.7

* In V1 this item was two questions: I will apply what I learned through completing this module to my learning [in this class] / [in other classes].

Table 16 compares evaluations for versions 1 and 2 of the motivation module. Enjoyment with the new module is higher—a positive result from the change in tutorial topics. However, the understanding of motivation may have decreased slightly.

Table 16. Comparison of student evaluations of versions 1 (N=443-450) and 2 (N=49)
Strongly Agee = 5, Strongly Disagree = 1

	Avg V1	Avg V2
I thought the module was easy to use	3.75	3.76
I understand the different aspects of motivation after completing the module	3.82	3.66
I enjoyed working with the module	3.18	3.63
I think the strategies for improving motivation will help me become a better learner	3.61	3.76
I will apply what I learned through completing this module to my learning in my classes	3.43/3.52*	3.65

* In V1 this was two questions: I will apply what I learned through completing this module to my learning [in this class] / [in other classes].

Conclusions

The e-learning modules on learning styles and motivation have produced a large amount of data. Analysis of the data has provided useful insight about what students experience while taking the module. Results suggest that students are experiencing different learning styles and levels of motivation. The results also show that students are learning about learning styles and motivation and believe the presented strategies will help them improve their learning. Evaluation data from the modules has also been helpful for making improvements. In initial testing of the 2nd versions of the modules, evaluation results have generally improved.

Acknowledgements

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