Board 13: Work in Progress: Exploring Student Disposition in a Foundational Conservation Principles of Bioengineering Course

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I. Introduction

Good problem-solving approaches are foundational to being an engineer regardless of the problem that is being solved [1]. To this end, most biomedical engineering curricula begin the curriculum with a problem-solving course, typically based on conservation principles [2]. One of the first foundational textbooks for BME curricula was developed by Saterbak, which is used in hundreds of programs nationwide [3]. The text provides a structured problem-solving approach that is introduced in the first chapter and reinforced in each following chapter [3]. When teaching a course that fosters both process and content mastery, careful attention must be paid to problem-solving processes, which require a conceptual understanding. Previous studies have shown that several factors lead to success in problem-solving such as student interest in the prompts, clear explanations, and engaging in reflective practices [1].

In order to measure students' attitudes toward a course, we leveraged findings from two related studies, where students were asked to answer a questionnaire with 60 questions related to disposition that was taken from the following validated instruments: the Index of Learning Styles[4], the Growth Mindset Scale[6], and sense of belonging questionnaire [7] and combined into a single survey [8,9]. The study identified a few key indicators of student disposition that showed a strong correlation in performance in conceptual problem-solving courses, as determined by the final grade: Reflector/activist traits from the Index of Learning Styles survey, belonging in the class, and growth mindset [8,9]. We will herein refer to this as the disposition survey.

Given these predictors of success in engineering courses, we sought to explore how students perceive changes in their disposition toward a course. Our research questions were 1) What is the incoming disposition of students in a sophomore problem-solving course and do students perceive a change in their disposition after 8 weeks in the class? 2) How do students articulate changes in their disposition during the course? 3) What structural and practical elements of the course support positive changes?

II. Methods

The course used for this study was a sophomore-level required course entitled "Conservation Principles for Bioengineering". This course is a problem-solving course that focuses on applying math, science, and biology knowledge obtained from other courses within a problem-solving framework. The course emphasizes a conceptual understanding of problems to apply a structured problem-solving strategy across multiple types of problems in bioengineering. The course features a lecture in week 1 that includes an overview of learning styles, growth mindset, and reflective practices for academic success. Concepts from this lecture are reiterated throughout the course by the instructor when solving example problems using the problem-solving process.

A cohort of students was recruited in Fall 2023 and provided consent to a University of Illinois Urbana-Champaign approved IRB Study #22209 to be a part of the study for a starting sample size of 76. The disposition survey (Survey 1) was administered via Qualtrics in the week leading up to the semester through the first week of class to capture students' incoming disposition toward the course. In week 8, students were provided their individual disposition survey results from week 1 and were asked a series of questions about their current disposition and changes in their disposition since week 1 (Survey 2). Survey 2 was also administered via Qualtrics and included a combination of Likert and open-ended questions that related to the research questions. A total of 19 from the original 76 consented students completed Survey 2. Both survey instruments are included in the Appendix.

We implemented a mixed-methods approach using quantitative and qualitative research methods together to fulfill research objectives [10]. The quantitative data collected from the survey was analyzed using descriptive statistics and the qualitative data obtained through the open-ended responses were analyzed using thematic analysis with a pragmatic grounded approach [11].

III. Results and Discussion

Pre-Course Disposition Survey Analysis (Research Question 1)

Results of the self-reported disposition survey are summarized in Table 1. Students in the course reported a moderate sense of belonging and growth mindset as they entered the course. Students scored low on the reflective learning scale, meaning that they are quick to start solving problems, instead of stepping back and thinking about the framing of a problem.

Table 1. Survey 1 responses. N=76 The scale 1 = none at all, 5 = a great deal. Average and Standard deviation are reported for each item.

Item	Belonging	Growth Mindset	Reflective Learning
Average	3.96	3.59	2.48
Std. Dev.	0.86	0.94	0.96

Mid-Semester Disposition Survey Quantitative Results

In Survey 2, when students were given a choice of increase, no change, or decrease in each of the disposition factors, the results showed that 63% reported an increased sense of belonging, 63% reported an increased growth mindset and 68% reported an increase in use of reflective learning approaches by week 8. The remaining respondents reported no change.

Mid-Semester Disposition Survey Qualitative Results (Research Questions 2 and 3)

Students were asked to comment on any changes in their disposition toward the class. Three main themes emerged from the open-ended responses related to student articulation of disposition (Table 2). Each theme emerged from a grouping of sub-themes.

Table 2. Survey 2 Open-ended response themes for disposition changes and effects. Theme, example quotes, and the number of associated quotes for each theme are reported. N=19

Theme	Example Quote(s)
Positive Disposition (11): Students emphasized the importance of having a positive disposition in influencing one's performance and attitude toward learning.	"My increased growth mindset has allowed me to face adversity with a positive outlook."
Challenges and Perseverance (3): Students recognized challenges in the course and the importance of maintaining a positive disposition to overcome obstacles and keep working towards improvement.	"As the semester continues, and work gets harder, it is definitely important to have a positive mindset to keep persevering."
Uncertainty and Fluctuations in Disposition (4): These quotes reveal that disposition can fluctuate, and individuals may experience uncertainty or a need for self-improvement in managing their disposition.	"With my current mindset, I think I need to be more of a reflector to achieve my own expectations."

In summary, these quotes demonstrate the complex relationship between disposition and performance in a class. They show that a positive and growth-oriented mindset can enhance motivation, perseverance, and problem-solving abilities. Further, students realize that they may also experience fluctuations in their disposition over time, so awareness is critical to maintaining a positive disposition. Overall, the themes highlight the importance of maintaining a positive to achieve success in an academic setting.

Five main themes emerged from the open-ended responses related to course elements that led to any changes in disposition (Table 3). Each theme emerged from a grouping of sub-themes.

Table 3. Survey 2 Open-ended response themes for course elements. Theme, example quotes, and the number of associated quotes for each theme are reported. N=19

Theme	Example Quote(s)
Engaging and Interesting Instruction (5): Students report engaging and interesting instruction, where the course content, problem-solving, and teaching methods contribute to an enjoyable learning experience.	"To be honest, at the beginning of the semester, I thought that I was going to hate this course, but you have made it genuinely interesting for me."
Supportive Instructor and Teaching Team (12): **Students** emphasized having a supportive instructor and teaching team who create a positive and approachable learning environment.	"Thank you for always asking for and being open to feedback."
Effective Communication and Explanation (4): Students appreciate effective communication and clear explanations in and out of class.	"I like it when you go through the problems step by step in order to better our understanding."
Interactive and Participatory Learning (3): Students expressed a preference for interactive and participatory learning experiences, including group activities and creative problem-solving tasks.	"I like the group activities in each lecture." "I also really appreciate that we get to use GradeScope for in-class activities and homework."
Efficient Grading and Feedback (3): Students highlight the importance of timely grading and constructive feedback in the learning process.	"Everything is graded quickly which is nice because then I have time to improve between assignments." "I do like to see where I lost points to know what I might need to ask about."

In summary, the thematic analysis of the quotes emphasize the importance of a supportive instructor and teaching team above all others, but also providing engaging and interesting instruction, effective communication, interactive learning experiences, in order to have a positive impact of these factors on students' motivation and enjoyment of the course. It also underscores the value of efficient grading and feedback in the learning process to motivate between assignments.

IV. Conclusions and Future Work

Ongoing research is being done to determine the changes in disposition using a pre/post survey that captures the disposition in week 1 as well as disposition in weeks 8 and 16 rather than relying on student-perceived changes. Additionally, more reflections are being added to expand the understanding of the impact of different course elements and the timing of any shifts in disposition during the course. This study was further limited in terms of the response rate for the second survey, which may lead to bias in the results of the qualitative findings. Future work will include correlations of perceived learning experience to direct assessment of learning through performance and grades in the course. We hope that these further insights will help instructors identify changes that can be made to enhance student disposition toward difficult courses in their curriculum.

V. Acknowledgments

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References

[1] Mourtos, Nikos J. "Challenges students face when solving open-ended problems." International Journal of Engineering Education (2010).
[2] Amos, Jennifer R., and Gabriella R. Dupont. "Work in progress: Are we on track with tracks?." In ASEE Annual Conference and Exposition, Conference Proceedings, vol. 2018. 2018.
[3] Saterbak, Ann, Ka-Yiu San, and Larry V. McIntire. Bioengineering fundamentals. Upper Saddle River, NJ: Pearson Prentice Hall, 2007.
[4] B.A. Soloman and R.M. Felder. 2011. Index of learning styles questionnaire. http://www.engr.ncsu.edu/learningstyles/ilsweb.html. Retrieved from North Carolina State University on August 4, 2011.
[5] C.S. Dweck. 2006. Mindset: The new psychology of success. New York: Random House.
[6] E.L. Deci and R.M. Ryan. 2012. Self-determination theory. In Handbook of theories of social psychology, P.A.M. van Lange, A.W. Kruglanski, and E.T. Higgins (Eds.). Sage Publications Ltd., 416–436.
[7] Catherine Good, Aneeta Rattan, and Carol S Dweck. 2012. Why do women opt out? Sense of belonging and women's representation in mathematics. J. Pers. Soc. Psychol. 102, 4 (2012), 700–717.
[8] Alvarez, Juan, Jennifer R. Amos, Yael Gertner, and Benjamin Cosman. "Identifying Student Profiles Related to Success in an Analog Signal Processing Course." In 2023 ASEE Annual Conference & Exposition. 2023.
[9] Gertner, Yael, Juan Alvarez, Benjamin Cosman, and Jennifer R. Amos. "Identifying Student Profiles Related to Success in Discrete Math CS Courses." In 2023 ASEE Annual Conference & Exposition. 2023.
[10] Creswell, John. 2014. Research design: Qualitative, quantitative, and mixed methods approaches, 4th edn. United States of America: SAGE Publications.
[11] McCall, Cassandra, and Cherie Edwards. "New perspectives for implementing grounded theory." Studies in Engineering Education 1, no. 2 (2021).

SIIP Pre-Course Survey

Start of Block: Block 1

Q51 What is your level of familiarity with MATLAB?

- Never used it before (None) (1)
- Some experience, basic skills (Basic) (2)
- Lots of experience, basic skills (Good) (3)
- Lots of experience, advanced skills (Expert) (4)

Q52 What math courses have you completed or are currently enrolled for Fall 2020?

- [ ] Calculus I - Differential (1)
- [ ] Calculus II - Integral (2)
- [ ] Calculus III - Multivariate (3)
- [ ] Differential Equations (4)
- [ ] Linear Algebra (5)
- [ ] Statistics (6)

Attitudes and Belong Read each sentence below and then select the one answer that shows how much you agree with it. There are no right or wrong answers.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I think this class is going to be boring (1)	○	○	○	○	○
I think this class is going to be enjoyable (2)	○	○	○	○	○
I think that I am going to be pretty good at this class (3)	○	○	○	○	○
This is a class that I cannot do very well in (4)	○	○	○	○	○
I plan to put a lot of effort into this class (5)	○	○	○	○	○
It is important to me to do well in this class (6)	○	○	○	○	○
I am anxious about this class (7)	○	○	○	○	○
I feel very relaxed about this class (8)	○	○	○	○	○
I feel like it is not my own choice to do this class (9)	○	○	○	○	○
I feel like I am taking this class because I have to (10)	○	○	○	○	○
I believe this class could be of some value to me (11)	○	○	○	○	○
I believe doing this class is important (12)	○	○	○	○	○

My family sees me as a bioengineer (13)	○	○	○	○	○
My friends/classmates see me as bioengineer (14)	○	○	○	○	○
My instructors/teachers see me as a bioengineer (15)	○	○	○	○	○

Growth Mindset Read each sentence below and then select the one number that shows how much you agree with it. There are no right or wrong answers.

	Strongly agree (1)	Agree (2)	Somewhat agree (3)	Somewhat disagree (4)	Disagree (5)	Strongly disagree (6)
You have a certain amount of intelligence, and you can't really do much to change it. (1)	○	○	○	○	○	○
Your intelligence is something about you that you can't change very much (2)	○	○	○	○	○	○
You can learn new things, but you can't really change your basic intelligence. (3)	○	○	○	○	○	○

Q47 You may only choose one answer for each question, and you must answer all questions before you can submit the form. If both answers to a question seem to apply to you, choose the one that applies more frequently throughout all your courses.

Q3 I understand something better after I

- ○ try it out (1)
- ○ think it through (2)

Q4 I would rather be considered

- ○ realistic (1)
- ○ innovative (2)

Q5 When I think about what I did yesterday, I am most likely to get

- ○ a picture (1)
- ○ words (2)

Q6 I tend to

- ○ understand details of a subject but may be fuzzy about its overall structure. (1)
- ○ understand the overall structure but may be fuzzy about details. (2)

Q7 When I am learning something new, it helps me to

- ○ talk about it (1)
- ○ think about it (2)

Q8 If I were a teacher, I would rather teach a course

- that deals with facts and real life situations (1)
- that deals with ideas and theories. (2)

Q9 I prefer to get new information in

- pictures, diagrams, graphs, or maps. (1)
- written directions or verbal information. (2)

Q10 Once I understand

- all the parts, I understand the whole thing. (1)
- the whole thing, I see how the parts fit. (2)

Q11 In a study group working on difficult material, I am more likely to

- jump in and contribute ideas. (1)
- sit back and listen. (2)

Q12 I find it easier

- to learn facts. (1)
- to learn concepts. (2)

Q13 In a book with lots of pictures and charts, I am likely to

- look over the pictures and charts carefully. (1)
- focus on the written text. (2)

Q14 When I solve math problems

- I usually work my way to the solutions one step at a time. (1)
- I often just see the solutions but then have to struggle to figure out the steps to get to them. (2)

Q15 In classes I have taken

- I have usually gotten to know many of the students. (1)
- I have rarely gotten to know many of the students. (2)

Q16 In reading nonfiction, I prefer

- something that teaches me new facts or tells me how to do something. (1)
- something that gives me new ideas to think about. (2)

Q17 I like teachers

- who put a lot of diagrams on the board. (1)
- who spend a lot of time explaining. (2)

Q18 When I'm analyzing a story or a novel

- ○ I think of the incidents and try to put them together to figure out the themes. (1)
- ○ I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them. (2)

Q19 When I start a homework problem, I am more likely to

- ○ start working on the solution immediately. (1)
- ○ try to fully understand the problem first. (2)

Q20 I prefer the idea of

- ○ certainty. (1)
- ○ theory. (2)

Q21 I remember best

- ○ what I see. (1)
- ○ what I hear. (2)

Q22 It is more important to me that an instructor

- ○ lay out the material in clear sequential steps. (1)
- ○ give me an overall picture and relate the material to other subjects. (2)

Q23 I prefer to study

- in a group. (1)
- alone. (2)

Q24 I am more likely to be considered

- careful about the details of my work. (1)
- creative about how to do my work. (2)

Q25 When I get directions to a new place, I prefer

- a map. (1)
- written directions. (2)

Q26 I learn

- at a fairly regular pace. If I study hard, I'll "get it." (1)
- in fits and starts. I'll be totally confused and then suddenly it all "clicks." (2)

Q27 I would rather first

- try things out. (1)
- think about how I am going to do it. (2)

Q28 When I am reading for enjoyment, I like writers to

- clearly say what they mean. (1)
- say things in creative, interesting ways. (2)

Q29 When I see a diagram or sketch in class, I am most likely to remember

- the picture. (1)
- what the instructor said about it. (2)

Q30 When considering a body of information, I am more likely to

- focus on details and miss the big picture. (1)
- try to understand the big picture before getting into the details. (2)

Q31 I more easily remember

- something I have done. (1)
- something I have thought a lot about. (2)

Q32 When I have to perform a task, I prefer to

- master one way of doing it. (1)
- come up with new ways of doing it. (2)

Q33 When someone is showing me data, I prefer

- charts or graphs. (1)
- text summarizing the results. (2)

Q34 When writing a paper, I am more likely to

- work on (think about or write) the beginning of the paper and progress forward. (1)
- work on (think about or write) different parts of the paper and then order them. (2)

Q35 When I have to work on a group project, I first want to

- have "group brainstorming" where everyone contributes ideas. (1)
- brainstorm individually and then come together as a group to compare ideas. (2)

Q36 I consider it higher praise to call someone

- sensible. (1)
- imaginative. (2)

Q37 When I meet people at a party, I am more likely to remember

- what they looked like. (1)
- what they said about themselves. (2)

Q38 When I am learning a new subject, I prefer to

- stay focused on that subject, learning as much about it as I can. (1)
- try to make connections between that subject and related subjects. (2)

Q39 I am more likely to be considered

- outgoing. (1)
- reserved. (2)

Q40 I prefer courses that emphasize

- concrete material (facts, data). (1)
- abstract material (concepts, theories). (2)

Q41 For entertainment, I would rather

- watch television. (1)
- read a book. (2)

Q42 Some teachers start their lectures with an outline of what they will cover. Such outlines are

- somewhat helpful to me. (1)
- very helpful to me. (2)

Q43 The idea of doing homework in groups, with one grade for the entire group,

- appeals to me. (1)
- does not appeal to me. (2)

Q44 When I am doing long calculations,

- I tend to repeat all my steps and check my work carefully. (1)
- I find checking my work tiresome and have to force myself to do it. (2)

Q45 I tend to picture places I have been

- easily and fairly accurately. (1)
- with difficulty and without much detail. (2)

Q46 When solving problems in a group, I would be more likely to

- think of the steps in the solutions process. (1)
- think of possible consequences or applications of the solution in a wide range of areas. (2)

End of Block: Block 1

SIIP Study Skills Feedback

Start of Block: Default Question Block

Q2 How pleased are you with your performance in the class?

- Extremely displeased (1)
- Somewhat displeased (2)
- Neither pleased nor displeased (3)
- Somewhat pleased (4)
- Extremely pleased (5)

Q3 How pleased are you with your understanding of the course material?

- Extremely displeased (1)
- Somewhat displeased (2)
- Neither pleased nor displeased (3)
- Somewhat pleased (4)
- Extremely pleased (5)

Q12 You received a link to your Mindset Plot along with this survey request, please view your Mindset Plot before answering the following questions.

Q1 How well do you feel that the plot describes your disposition at the beginning of the semester?

	Does not describe my feelings (1)	Slightly describes my feelings (2)	Moderately describes my feelings (3)	Mostly describes my feelings (4)	Clearly describes my feelings (5)
Motivation - Expectancy (1)	○	○	○	○	○
Motivation - Value (2)	○	○	○	○	○
Belonging (3)	○	○	○	○	○
Growth Mindset (4)	○	○	○	○	○
Reflective/Activist (5)	○	○	○	○	○

Q4 How much do you feel that your disposition has affected your performance in the class so far?

- ○ None at all (1)
- ○ A little (2)
- ○ A moderate amount (3)
- ○ A lot (4)
- ○ A great deal (5)

Q15 In your mind, did the value of this class change since the beginning of class when you filled out the survey?

- ○ Increased
- ○ No change
- ○ Decreased

Q16 In your mind, did your interest in this class change since the beginning of class when you filled out the survey?

- ○ Increased
- ○ No change
- ○ Decreased

Q17 In your mind, did you experience a change in you sense of belonging since the beginning of class when you filled out the survey?

- ○ Increased
- ○ No change
- ○ Decreased

Q18 In your mind, did your learning style become more reflective since the beginning of class when you filled out the survey?

- ○ Increased
- ○ No change
- ○ Decreased

Q19 In your mind, did your growth mindset change since the beginning of class when you filled out the survey?

- ○ Increased
- ○ No change
- ○ Decreased

Q6 How do you feel your disposition is going to affect your performance going forward?

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_____

_____

_____

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Q13 Please comment on any changes in your disposition during this course.

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Q20 Please comments on any course elements that influenced changes in your disposition during this course.

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End of Block: Default Question Block