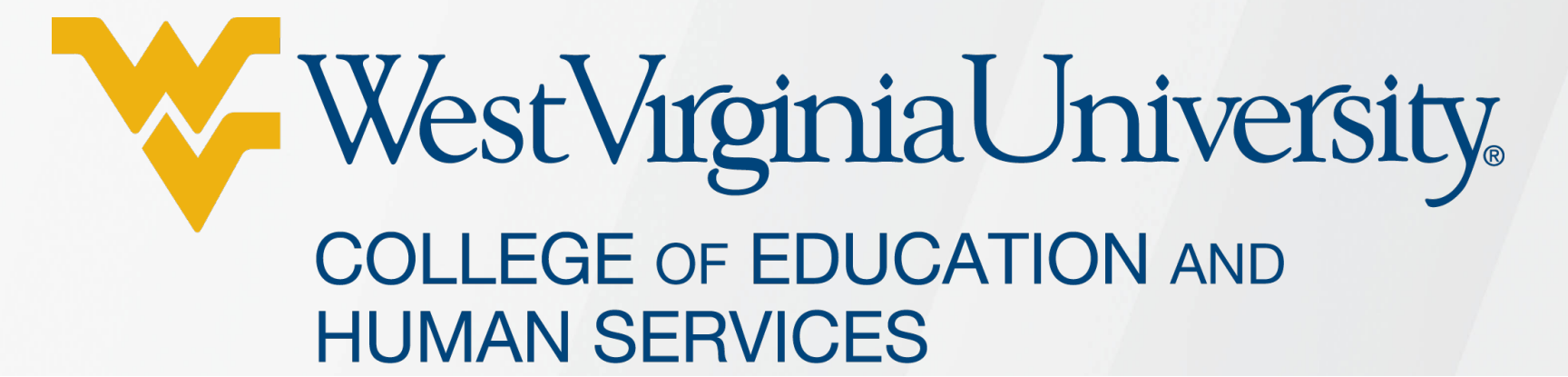


Undergraduate Students' Experience of Surprise Caused by Exam Performances in Foundational Engineering Classes

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Background

- What is surprise?
 - A primary epistemic emotion (emotion that is related to the knowledge-generating aspects of cognitive activities)
 - The expectancy-disconfirmation model (Meyer et al., 1991, 1997): People experience surprise in the event of expectancy disconfirmation.
 - The first emotion that occurs when people are confronted with events incongruent with their expectations (Muis et al., 2018; Vogl et al., 2019)
 - Can be either positive or negative, depending on the valence of the outcome (Neta et al., 2009; Noordewier et al., 2016; Noordewier & Breugelmans, 2013)
 - The intensity of surprise is affected by the **importance, valence, and unexpectedness** of an outcome (Gendolla, 1997; Gendolla & Koller, 2001). The highest level of surprise will be experienced after an important failure.
- The working mechanism of surprise
 - Begins with an appraisal of whether the event exceeds some discrepancy/unexpectedness threshold
 - Continues with
 - The occurrence of the feeling of surprise
 - The interruption of other ongoing cognitive processes, and the reallocation of cognitive processing resources to the surprising event to prepare for the analysis of the event
 - Ends with an evaluation of the event and, if necessary, an update of one's schema (Gerten & Topolinski, 2019; Reisenzein et al., 1996)
- Undergraduate engineering students are likely to experience surprise when they fail foundational courses or earn grades lower than expected.
 - Engineering foundational courses are **important**
 - Required for all students and cover content that is essential for students' learning in subsequent professional engineering courses
 - Students tend not to perform well in foundational courses
 - About a third of engineering students do not earn the required minimum grade for the engineering major (at least a C) (Gainen, 1995; Summerville et al., 2018).
 - Failure in foundational courses lead to many consequences (**negative valence**):
 - Causes attrition from engineering: Low performance in foundational courses is one of the main reasons students leave engineering programs (Huang & Pierce, 2015)
 - Diminishes the likelihood of success in later engineering courses (Call et al., 2015)
 - Delays the completion of degrees
 - Erodes students' motivation and confidence (Shew et al., 2019)
 - Causes students to lose their scholarships
 - Failing foundational courses can be **unexpected** for students:
 - College engineering students typically performed well during high school (Shew et al., 2019)
 - They have a significantly higher confidence in their abilities than students in other majors (Veenstra et al., 2008)
- Impacts of surprise on student learning
 - When the discrepant information is of high value and is comprehensible, surprise may transition into curiosity (Muis et al., 2018).
 - How will curiosity affect learning?
 - Curiosity relates to exploratory behaviors (Litman, 2005)
 - It predicts self-regulation including planning, goal setting, and monitoring and evaluation of learning (Morton, 2010; Muis et al., 2015)
 - It also predicts shallow cognitive strategies (Muis et al., 2015)
 - When the discrepant information is incomprehensible, surprise may be followed by confusion (Muis et al., 2018)
 - How will confusion affect learning?
 - Does not predict exploratory behaviors (Vogl et al., 2019)
 - If appropriately regulated, can lead to deep processing of information (D'Mello S. et al., 2014)
 - If not regulated, can lead to frustration or disengagement (D'Mello & Graesser, 2012)
 - So, surprise needs to be appropriately regulated.**

The following research questions were addressed:
 RQ1: Did students experience surprise in foundational engineering courses?
 RQ2: What were the causes of students' surprise?

Method

Participants

- Students in the Engineering Statics class

Data Collection

- Reflections (46 reflections)
 - Took three exams: forty minutes; four problems participants needed to solve
 - Reflected on surprise:
 - The next day after each exam, participants estimated their exam scores. A video explaining the problem solutions and how the instructor would grade the test paper was available.
 - After this estimation, participants wrote a reflection by following a template
 - Reflection template:
 - Rated levels (0-4) of surprise, liking, and expectancy
 - Responses to questions related to the three indicators of surprise
 - An experiential indicator of surprise (**surprise**) (i.e., why were you surprised?)
 - An indicator of affective response (**liking**) (i.e., why do you like or dislike your score?)
 - A cognitive appraisal of unexpectedness (**expectancy**) (i.e., why did you expect or did not expect such a score?)
- Gerten & Topolinski, 2019; Noordewier et al., 2016; Noordewier & Breugelmans, 2013)

Reflection Prompt

Students feel surprised when their exams scores are different from their expectations. Now that you just learned about your exam score, we would like you to reflect on whether you were surprised by your score and what you are going to do in the future.

- Please rate your level of surprise with your earned score. (0 = not at all surprised, 1 = slightly surprised, 2 = moderately surprised, 3 = very surprised, 4 = extremely surprised.)
- Why are you surprised or not surprised?
- How much do you like your score? (0 = not at all, 1 = slightly, 2 = moderately, 3 = very much, 4 = extremely.)
- Why do you like or do not like your score?
- How much did you expect a score like the one you got? (0 = not at all, 1 = slightly, 2 = moderately, 3 = very much, 4 = extremely.)
- Why you expected or did not expect a score like the one you got? Please be specific. For example, if you expected to earn a high grade because you spent much time on the course, describe how you spent your time. If you thought you understood all concepts, but still scored low on the exam, describe what you did to understand the concepts.
- What were the other feelings you experienced when you learned about your exam score?
- What will you do to become more successful in the remainder of the semester?
- How do you think your instructor can help you become more successful in the remainder of the semester?

Data Analysis

Inductive: looked for themes (e.g., causes of surprise) that emerged from the data, not a process of fitting the data into an existing coding scheme

Results

Participants' Ratings of Their Surprise, Expectancy, and Liking of Test Scores

	Unpleasant surprise	Pleasant surprise	Expectancy	Liking
Level 0	1	3	9	21
Level 1	15	2	13	3
Level 2	10	4	9	8
Level 3	4	1	12	9
Level 4	5	0	2	5
Total	35	10	45	46

Results (Cont.)

One Case: One Participant's Reflections on Three Exams Throughout the Semester

Participant	Exam 1			Exam 2			Exam 3		
	Level of surprise and why	Level of liking and why	Level of expectancy and why	Level of surprise and why	Level of liking and why	Level of expectancy and why	Level of surprise and why	Level of liking and why	Level of expectancy and why
Amy (C10) (pleasant surprise)	Level: 1 Not too surprised because she found the test to be extremely difficult.	Level: 0 Enjoyed the class and wanted to do well, but didn't do well.	Level: 2 Did not fall behind on homework or lecture videos. Studied hard for the test by going over homework problems and lecture videos. Spent more time on this class than other classes.	Pleasant surprise level: 2 Thought understood the materials, but did not expect to do as well as the projected score.	Level: 4 Worked very hard to understand the material and wanted to get a good grade she deserved. She thought she did it this time.	Level: 1 "I studied very hard and actively watched all the lecture videos. What I changed was ... I worked [extra] problems from the textbook and went over some of the more difficult homework problems."	Level: 1 She thought she prepared well and felt good going into the exam.	Level: 3 "I am happy with Bs in this class especially when I worked hard for them."	Level: 2 "I prepared for this exam like last exam, so I did expect to do ok on it."

Causes of surprise	Unpleasant surprise: <ul style="list-style-type: none"> Thought they understood all materials, but they still scored low Surprised by too many simple mistakes (However, all participants who mentioned that their simple errors surprised them were slightly surprised (a surprise level of 1). Surprised that enough time to finish the test Pleasant surprise: <ul style="list-style-type: none"> Thought they did well after completing the tests, but their scores were even higher than expected.
Causes of liking/disliking	Did not like their scores: <ul style="list-style-type: none"> Too low or even a failing grade Thought their scores did not reflect their knowledge Scores were lower than expected Four out of the seven reflections that mentioned that their scores were too low were NOT surprised by the scores. They were not surprised because they found the test to be extremely difficult, they did not finish the test, or they did not study much. Liked their scores: <ul style="list-style-type: none"> Scores were high
Causes of expectancy	Why expected good scores: <ul style="list-style-type: none"> Understood all concepts Studied hard for the tests Why expected low scores (not many) <ul style="list-style-type: none"> Did not study much

Present Study

This study examined undergraduate students' experience of surprise caused by exam scores in foundational engineering courses. This is significant because:

- Few field studies have explored college students' feelings of surprise, especially in the context of engineering education, although there is a wealth of laboratory research on surprise (e.g., its antecedents, consequences, procedural architecture, etc.) (e.g., Gendolla & Koller, 2001; Levy et al., 2018; Meyer et al., 1997) and recently researchers attend to the role of epistemic emotions in learning (Muis et al., 2018; Vogl et al., 2019).
- For the engineering education community, an understanding of the surprise can inform how to regulate students' surprise.

Discussion

Students did experience surprise:

- Surprise (negative) level was 3 or 4 (level ranging from 0 to 4) in 21.7% of the reflections
- Expectancy level was 0 and 1 in 47.83% of the reflections
- Liking level was 0 and 1 in 52.17% of the reflections

Students tended to have inaccurate assessment of their knowledge, which led to surprise. Interventions needed to help students assess their own knowledge (Metacognition)

Some students did not study for test in advance, did not watch the lecture videos every day, or did not do well in homework. Intervention needed to help students self-regulate their learning (Self-regulation)