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Motivations of Students in a Thermodynamics Course

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Abstract

Students have different motivations when it comes to being successful in college. Some are driven by their own curiosity and interest in the topics they are studying. Others are driven by their need to earn high grades or their fear of falling short of expectations. Motivated students tend to be more successful in college, so it is important that those motivations are understood. With more knowledge of their students' motivations, professors can be more effective in the classroom.

The current study analyzes the data from an anonymous survey given to students enrolled in Thermodynamics in the fall semester at two public universities, Mississippi State University and North Carolina State University. Using a Likert scale, students indicated their level of agreement to statements about thermodynamics and engineering in general. The collected surveys provide insight into student opinions about their desire to learn, their ability to deal with uncertainty, and their capacity for overcoming obstacles. Generally, the strongest agreement was for third-person statements about the work of an engineer and the weakest agreement was for first-person statements about personal experiences.

Keywords

Thermodynamics, motivation

Introduction

It is well known that engineering courses can be very challenging for students. This difficulty affects student perceptions of engineering and their motivation to pursue an engineering career. A study by Krajkovich and Smith [4] identified misconceptions and stereotypes that students had about scientists so that "misconceptions may be resolved and thus inspire some students to seek a career in science". Understanding and increasing students' motivations should be an important goal for engineering education. Hong and Lin-Siegler [5] showed that student performance and motivation in STEM courses can be impacted by their image of scientists, a related STEM field. They also showed how motivation and performance can be positively impacted by showing a more realistic view of the path to scientific discovery. Students who learned about the struggles of famous scientists were more motivated and performed better in physics.

Researchers have found several relevant categories of motivation. Some distinguish between intrinsic (or personal) and extrinsic (or situational) motivation [2, 5]. Further, some consider different types of extrinsic goals. Lukes and McConnell [1] compared the performance of students motivated by good grades (performance-based motivation) and those motivated by learning (mastery-based motivation).

Many studies consider factors that could have an impact on motivation. For example, several studies have considered student's feelings about performance in courses or career outcomes.

Lukes and McConnell [1] found that high performing students tend to be more motivated by avoiding a negative emotion than by approaching a positive emotion. Lockwood et al [3] studied how students' perspectives on performance affects what type of role models can impact their motivation. Students focused on avoiding negative outcomes are more motivated by negative role models to avoid, while students focused on pursuing positive outcomes were more motivated by positive role models.

This study presents the results of a survey that was given to Thermodynamics I students at Mississippi State University and North Carolina State University. The survey assesses student motivation as well as student views that may impact motivation including views on failure, views on engineering work, and views of engineers.

Methods

An anonymous survey was given to students during the second week of the fall semester. The survey data was then analyzed to determine any trends in the results relative to student majors and number of years in school. The twenty-question survey focused on four areas: the desire to learn thermodynamics, the ability to learn from failure, the ability to deal with uncertainty, and the image of an engineer.

Table 1 shows the data that was self-reported by the study participants. Twelve of the respondents are juniors in mechanical engineering that attend Mississippi State University. A majority of the respondents who are not mechanical engineers are aerospace engineers. Most of the seniors are not mechanical engineering majors. A five-point Likert Scale was used in this survey with one for "strongly agree" and five for "strongly disagree". Some statements were reversed to make sure the data was valid and to decrease acquiescence bias.

Table 1. Survey participants

Number of respondents	*Mechanical Engineers*	*Other Majors*	
119	68	51	
	Sophomores	*Juniors*	*Seniors*
	22	81	16

Results and Discussion

The analysis of the survey data was first completed per topic of statements based on the means and standard deviations. The reversed statements are noted in each table. However, the data was not reversed so those statements have the highest means.

Table 2 shows the survey data for statements 1 through 5 that assessed the student's desire to learn thermodynamics. Each statement was written in the first-person perspective. For all majors and all years, the strongest agreement is seen with statement 3 indicating that grades are the most motivating factor for students. The next strongest agreement is for statement 2 which refers to studying. While it is encouraging that students recognize that they need to devote time to studying, the motivation seems to come more from grades than curiosity or interest (statements 1 and 5, respectively). For each of these statements, the mechanical engineering (ME) majors more strongly agreed (or more strongly disagreed in the case of the reversed statement 4) than the other majors. The ME majors also had smaller standard deviations indicating good agreement among all responses.

Table 2. Responses to statements about the desire to learn

1. I am curious about the topics discussed in thermodynamics.

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	2.00	2.29		2.05	2.06	2.56
SD	0.728	0.914		0.767	0.775	0.998

2. I plan to dedicate a lot of time to gain an understanding of thermodynamics.

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	1.81	2.08		2.05	1.90	1.88
SD	0.791	0.813		0.928	0.795	0.696

3. I plan to dedicate a lot of time to earn a good grade in thermodynamics.

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	1.57	1.96		1.86	1.69	1.81
SD	0.714	0.949		0.868	0.841	0.808

4. I don’t feel that this course will benefit my career. (reversed)

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	4.07	3.67		3.95	3.96	3.50
SD	0.975	1.04		1.021	0.987	1.118

5. I find thermodynamics very interesting.

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	2.35	2.69		2.36	2.49	2.69
SD	0.836	0.980		0.828	0.918	0.982

When comparing responses among the different years, there is not a large difference between the means for each statement. The largest standard deviations are seen for statement 4, which suggests that some students taking the course have career plans in mind and know the importance, or lack thereof, of thermodynamics in those plans.

The responses to the next five statements show students’ opinions on learning from failure, as seen in Table 3. The strongest agreement was for statement 10 and reversed statement 7, so most students understand that mistakes are unavoidable and are learning opportunities. These statements were the only ones in this table written in the third person and referring to engineers. The other statements (6, 8, and 9) refer to student activities in the first person and had mostly higher standard deviations indicating a wider range of responses and less consensus on these statements. Also notable is the data for statement 8 that shows the largest difference between the means of the demographic categories and the only statement with each standard deviation above one. This analysis suggests that test anxiety is a bigger issue for ME and younger students.

Table 3. Responses to statements about learning from failure

	ME	Other		Sophomores	Juniors	Seniors
6. Asking for help to find a solution means that I am unable to learn the material on my own. (reversed)						
Mean	3.84	3.76		3.77	3.77	4.06
SD	1.133	1.130		1.203	1.147	0.899
7. Good engineers are people who never make mistakes. (reversed)						
Mean	4.37	4.45		4.55	4.35	4.50
SD	0.922	0.935		0.940	0.905	1.00
8. Taking exams gives me a lot of anxiety because I am afraid of making a mistake. (reversed)						
Mean	2.07	2.63		1.95	2.33	2.69
SD	1.034	1.204		1.021	1.122	1.261
9. If I make a bad grade on an exam, then I probably don't belong in this program. (reversed)						
Mean	3.82	3.76		3.68	3.79	4.00
SD	0.907	1.130		0.972	0.978	1.173
10. Making a mistake in engineering is a good opportunity to learn.						
Mean	1.63	1.73		1.59	1.74	1.44
SD	0.784	0.930		0.778	0.872	0.788

Statements about dealing with uncertainty are shown in Table 4. Analysis of student responses indicate their strong agreement that experimentation is required for new technology (statement 11). They also strongly disagreed with reversed statement 13 regarding problems with only one right answer. However, for statement 12, students were mostly neutral on the first-person statement about questions with multiple answers. The last two statements' data show that students generally like new challenges but do not like starting a problem with uncertainty.

Table 5 provides the survey data for third-person perspective statements about the image of engineers. Overall, the major or year does not have a strong impact on a student's opinions on these statements, and all but one of the standard deviations are below one. The strongest responses for all majors and years were for reversed statements 19 and 20, so students agree that engineers need communication skills and that engineering designs do not always work the first time. Statement 16 shows the biggest difference between years in that sophomores are more likely to disagree than juniors that solutions follow a step-by-step procedure and seniors mostly agree.

Table 4. Responses to statements about dealing with uncertainty

11. Developing new technology requires experimentation.

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	1.44	1.41		1.32	1.51	1.19
SD	0.793	0.796		0.873	0.772	0.726

12. I dislike questions which could be answered in many different ways. (reversed)

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	3.15	3.41		3.23	3.19	3.69
SD	1.102	1.013		1.041	1.067	1.044

13. Engineering problems have only one right answer. (reversed)

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	4.13	4.10		4.36	4.06	4.06
SD	0.969	0.975		0.881	0.998	0.899

14. I can't start working on a problem until I understand all of the steps needed to complete the problem. (reversed)

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	2.69	3.06		3.14	2.65	3.44
SD	0.989	1.211		1.217	1.032	0.998

15. I like the challenge of a new type of problem that I have never faced before.

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	2.31	2.35		2.05	2.47	2.00
SD	0.879	0.788		0.824	0.818	0.791

Table 5. Responses to statements about the image of an engineer

16. Engineers can solve engineering problems by just following a step-by-step procedure. (reversed)

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	3.24	3.18		3.41	3.23	2.81
SD	0.957	0.984		0.887	0.946	1.073

17. Engineers are responsible for finding solutions to the world's problems.

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	2.06	2.12		2.05	2.12	1.94
SD	0.922	0.808		0.878	0.908	0.658

18. Engineers spend a lot of time building things.

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	2.75	2.92		2.73	2.81	3.00
SD	0.847	0.836		0.862	0.833	0.866

19. Engineers do not need strong communication or interpersonal skills. (reversed)

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	4.41	4.39		4.50	4.32	4.69
SD	0.895	0.930		0.892	0.954	0.583

20. The designs of good engineers always work the first time. (reversed)

	ME	*Other*		*Sophomores*	*Juniors*	*Seniors*
Mean	4.53	4.45		4.55	4.48	4.50
SD	0.776	0.800		0.722	0.833	0.612

Conclusions

Students in thermodynamics courses at two universities completed an anonymous survey about their motivations. The data was analyzed by major and year in school. There was no significant difference in the data when the respondents were separated by university. For all statements, the strongest agreement among the students was for statement 11 about experimentation for new technology, statement 10 about making mistakes, and reversed statement 20 about engineering designs. Each of these statements in the third person had low standard deviations which suggests strong agreement about what the work of an engineer requires. Overall, the highest standard deviations were found with the first-person statements. The participants were more in agreement when the statement referred to engineers than when the statement referred to their personal experiences.

Future work will attempt to gain better insight into multiple aspects of the current study. Research will focus on how to make students more interested in and curious about thermodynamics in order to better motivate them to learn. Also, student perceptions on failure will be investigated further. Students in this study consistently acknowledged that learning from failure is a necessary part of the engineering work in the field. However, this consensus did not translate to student feelings about low performance on academic work. Further research will focus on understanding the reason for this discrepancy and how to encourage students to see poor performance on academic work as learning opportunities.

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