

Lauvland, A., Bøe, M. V., & Henriksen, E. K. (2021):

MOTIVATION PROFILES AMONG FIRST-YEAR PHYSICS STUDENTS

Students with different degrees and types of motivation have different needs to become and stay engaged in physics learning. In this study, we conducted a survey among N=318 first-year university students measuring their motivations for learning physics. Expectancy-Value Theory was used to operationalize motivation and determine a five factor model for students' motivation to learn physics. Three motivational profiles were identified based on factor scores. The highly motivated students were associated with high interest, utility and attainment value to learn physics. This group also had low scores on the costs associated with learning physics, and high expectation of success. The moderately motivated students had mean scores of interest, utility, attainment, cost and expectation for success close to the mean of the entire group. And lastly, the less motivated students showed a lower degree of motivation across all factors, in addition to associating higher costs with learning physics. Students from three study program categories (Physics bachelor, Engineering, and Other) and from both genders were represented in each cluster, though not evenly distributed. In the highly motivated cluster, male students and physics bachelor students were overrepresented, whereas female students and engineering students were overrepresented in the less motivated cluster. The moderately motivated cluster had a more balanced distribution of study programs and genders. The results suggest that physics teaching needs to support and develop different motivations, paying special attention to less motivated students who require more support to stay engaged. We call for more research into how different learning activities interact with motivation for a broad range of students, and how teaching can better support their engagement.

Keywords: Higher education, physics, motivation.

INTRODUCTION

Motivation is highly predictive of choices of, retention in, and performance in education in general, and this is also true for physics (Bøe & Henriksen, 2013). In their study, Bøe & Henriksen (2013) found three motivation profiles, or choice profiles, among secondary physics students in Norway: The *intrinsic and extrinsic* profile, broadly motivated by interest-enjoyment, expectation of success, and utility for university admission; the *extrinsic* profile emphasizing mainly utility; and the *intrinsic* profile emphasizing mainly interest-enjoyment. They argued that traditional physics culture favors students with an intrinsic motivation profile, and that efforts to motivate larger and more diverse student groups in physics need to address this issue. In this study we move up to the university level and investigate students' motivation for learning higher education physics at five research intensive institution in Norway. With the aim to sustain and increase retention in higher education programs that include physics, we ask the following research question:

- Which motivation profiles can be found for students in introductory mechanics in Norway?

The answer to this question will shed light on how motivation varies within a student group, as well as underline the importance of providing learning activities that also engage students with less or different motivation than those who are most interested.

We use Expectancy Value (EV) theory to operationalize and assess students' motivation. Initially presented by Eccles and colleagues (Wigfield & Eccles, 2000), EV theory and has been applied to measure motivation and study student's choices of STEM-education in previous research. The framework is extensive; however, we focus on the two parts *Expectations for success* (ES) and *Subjective task value* (STV). In the model, they are separate constructs for explaining an individual's achievement related choice. The first construct, ES, relates to how well an individual thinks he/she will do on a specific task, and has much in common with self-efficacy. The STV construct consists of four aspects; *Interest enjoyment* (IE), *Attainment value* (AV), *Utility value* (UV) and *Cost*. IE encapsulates interest, and bears similarities to intrinsic motivation (Ryan & Deci, 2000). The AV aspect corresponds to how much the individual feels that completing the task is in accordance with their identity. The UV is the concrete gain from completing the task (e.g. obtaining an academic degree, good job), and it has much in common with extrinsic motivation (Ryan & Deci, 2000). Finally, cost is the negative subjective value of the individual's perceived cost of engaging in a task.

METHODS

N = 318 students responded to a survey consisting of approximately 100 Likert-type items and closed background questions. 15 items were designed to span operationalizations of the five constructs in Eccles' EV theory. We employed factor analysis and EV theory to determine a five factor model, where the five factors are the five factors from EV theory (IE, AV, UV, Cost and ES) was used to explain the variance in the data. Construct validity was ensured by confirmatory factor analysis (CFA) (Brown, 2015). The CFA was performed using lavaan (Rosseel, 2012) in R. We calculated predicted factor scores, and estimated each factor's internal consistency using Cronbach's α . All factors possessed $\alpha \geq 0.7$. The K-means clustering algorithm was used to find three clusters using the scores for the five factors. Background questions were used to group respondents according to their self-reported gender and study program. The survey question for gender had alternatives for "other" and "I prefer not to answer" in addition to "female" and "male". The overwhelming majority of the respondents identified as either "male" or "female". We identified three categories of study programs: Students who attend a Physics B.Sc.-program, engineering program and other programs. The "other" category of study programs includes mathematics, geology, teacher training, etc.

RESULTS

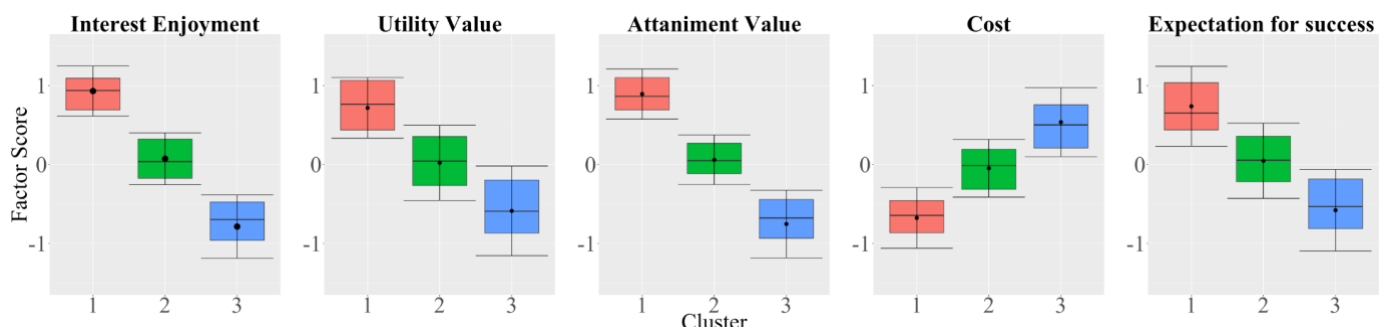


Figure 1. The three motivational clusters. Along the x-axis we see each motivational construct. On the y-axis is the factor score. The factor scores are normalized to have mean (for all respondents) equal to zero and variance 0,5. The horizontal of each box represent quartiles. The dots indicate within-cluster mean, and the whiskers indicate within-cluster standard deviation.

In figure 1 we see the results from the clustering. Here, the scale on the y-axes are normalized to the mean factor scores for all respondents, and the five different y-axes represent different factor scores according to each subplot's title. We see three distinct clusters. Cluster 1 is the highly motivated students, as they have high IE, UV, AV scores and subsequent low cost associated with learning physics, they also have a high ES. Cluster 2 is a moderately motivated group of students. This cluster's mean score is close to the mean for all participants across all five factors. Cluster 3 is the least motivated group. They are below average on IE, UV and AV and above average association of cost with learning physics. This group also has a below average ES.

Table 1. The number of respondents within each cluster by gender and study program. The sum of each row in the gender and study program categories amounts to the proportion of the subsequent cluster.

Cluster	N, Total	Male	Fem	Phys. B.Sc.	Eng.	Others
1	66	76%	24%	50%	33%	17%
2	154	56%	43%	36%	42%	22%
3	97	33%	63%	22%	44%	34%

In table 1 we see that the highly motivated group in cluster 1 is the smallest in the sample, and is dominated by male students who are mostly physics students, but the engineering students and other students are also in highly motivated cluster. The largest cluster 2 is dominated by engineering students, but all other study programs are represented. The less motivated group, cluster 3, is female-dominated with more students from engineering than the other study programs.

DISCUSSION AND CONCLUSION

We have found three motivational clusters among first year mechanics students in Norway; the highly, moderately, and less motivated students. Within the clusters we see male students dominate the highly motivated cluster and female students dominate the less motivated cluster, as expected from earlier research (Dou, Brewe, Potvin, Zwolak, & Hazari, 2018; Lindstrøm & Sharma, 2011). The cluster with moderately motivated students has a more balanced distribution in male/female students, and different study programs. The distribution of study programs and gender within each cluster provides valuable insight to the teaching of physics in higher education. As the survey measures motivation for learning physics, one could have a naïve notion that the highly motivated students are predominantly students attending a Physics B.Sc. program, and the least motivated students belong to less “physics oriented” study programs. However, we see that all study programs are represented in all clusters. This is a clear message to instructors of physics in higher education — several profiles of motivation (high, medium, low) exist in all subgroups of students and, consequently, in all classrooms. Teachers, therefore, need to facilitate for different kinds of motivation, i.e. by employing diverse instruction approaches. It is still common, however, for instructors to teach as they themselves were taught and motivated, often using traditional lectures and little interactive engagement (Fraser et al., 2014). Although most studies comparing traditional and active learning methods have focused on performance gains, students’ engagement and attendance also improve in active learning environments (ibid.). Traditional teaching may lead to narrow notions of what being a “good physics student” entails, for example by over-emphasizing abilities to calculate (Johansson, Andersson, Salminen-Karlsson, & Elmgren, 2018), failing to engage large groups of students. This is particularly unfortunate for the less motivated group, as they already have less motivation to carry them through struggles with difficulty and high workload, which they regard as costly. In our results we see that the less motivated group has of a significant proportion of students that attend a physics B.Sc. program and we also see an over-representation of women. Teaching in ways that only cater to the most interested students with the highest expectation of success goes against the goal of increasing the diversity in terms of gender, backgrounds, perspectives and outlooks in physics as well as reducing students opting out of physics entirely. This calls for more research into how different learning activities can spike and sustain motivation for a more, in a motivational sense, diverse group of students.

REFERENCES

- Bøe, M. V., & Henriksen, E. K. (2013). Love It or Leave It: Norwegian Students’ Motivations and Expectations for Postcompulsory Physics. *Science Education*. <https://doi.org/10.1002/sce.21068>
- Brown, T. A. (2015). *Confirmatory factor analysis for applied research*. Guilford publications.
- Dou, R., Brewe, E., Potvin, G., Zwolak, J. P., & Hazari, Z. (2018). Understanding the development of interest and self-efficacy in active-learning undergraduate physics courses. *International Journal of Science Education*, 40(13), 1587–1605. <https://doi.org/10.1080/09500693.2018.1488088>
- Fraser, J. M., Timan, A. L., Miller, K., Dowd, J. E., Tucker, L., & Mazur, E. (2014). Teaching and physics education research: Bridging the gap. *Reports on Progress in Physics*, 77(3). <https://doi.org/10.1088/0034-4885/77/3/032401>
- Johansson, A., Andersson, S., Salminen-Karlsson, M., & Elmgren, M. (2018). “Shut up and calculate”: the available discursive positions in quantum physics courses. *Cultural Studies of Science Education*, 13(1), 205–226. <https://doi.org/10.1007/s11422-016-9742-8>
- Lindstrøm, C., & Sharma, M. D. (2011). Self-Efficacy of First Year University Physics Students: Do Gender and Prior Formal Instruction in Physics Matter? *International Journal of Innovation in Science and Mathematics Education*, 19(2), 1–19.
- Rosseel, Y. (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*; Vol 1, Issue 2 (2012) . Retrieved from <https://www.jstatsoft.org/v048/i02>
- Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1), 68–78. <https://doi.org/10.1037/0003-066X.55.1.68>

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, 25(1), 68–81. <https://doi.org/10.1006/ceps.1999.1015>