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Tackling Differing Motivations: A Preemptive Look at Key Findings from a Systematic Literature Review of Achievement Goal Theory in Undergraduate STEM Motivations

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Tackling Differing Motivations Between the Sexes: A Preemptive Look at Key Findings from a Systematic Literature Review of Achievement Goal Theory in Undergraduate STEM Motivations

Abstract

This work-in-progress paper highlights the findings from a systematic literature review on the use of achievement goal theory in understanding undergraduate STEM student motivations. Motivation is a fundamental concept for understanding students and aiding them in navigating the challenges of academic study. For this paper, we focus on one theme uncovered during the literature review: biological sex differences in motivations. We wish to present the preliminary findings and elicit feedback from the community to ensure that we are accurately and responsibly presenting these findings.

Introduction

Achievement goal theory is a popular method for describing student motivations based on two main frameworks; mastering material or outperforming others (Covington, 2000; Seifert, 2004). Achievement goal theory has become a popular method of thinking about student motivations because it allows researchers to make inferences about the students' internal and external factors affecting their motivational framework (Bardach et al., 2020; Hinzman, 2011; Kaplan et al., 2002; Urdan & Schoenfelder, 2006). Within STEM education, achievement goal theory has not been used as extensively as in the fields of physical education (Chu & Zhang, 2018; Duda & Ntoumanis, 2003) and education (Harackiewicz et al., 2002; Pintrich et al., 2003). In engineering specifically, the use of achievement goal theory is severely limited (Heo et al., 2018), with the two most common lenses of motivation used being self-efficacy and self-determination theory (Brown et al., 2015). To understand how achievement goal theory is used in STEM education, we conducted a systematic literature review of achievement goal theory in undergraduate education, focusing mainly on STEM education literature.

Methods

We searched, reviewed, and analyzed the literature by (a) clearly stating our objectives, (b) identifying the journal articles and conference proposals that fit our eligibility criteria, (c) assessing the validity of the findings of those studies, and (d) conduct a systematic synthesis of evidence and presented them based on the characteristics and the findings of those studies. We followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 checklist (Page et al., 2021) while conducting our search. We began our examination of the relevant literature by searching the following research databases: Education Resource, ERIC, Education Full-Text, and APA PsychArticles. Then, we looked at Google Scholar and the ASEE PEER database. Our Boolean phrases shifted depending on the databases, but all looked at using some aspect of "achievement goal*" and "undergrad* STEM education."

Along with the Boolean phrases, some initial inclusion/exclusion criterion was included. Only English-language publications were included. Aside from the ASEE-PEER search, only peer-

reviewed journal articles were included. All publications or conference proceedings preceding 1996 were excluded. The reason for this exclusion was because this year marked a pivot for achievement goal theory, in which the introduction of the approach-avoidance axis was included (Elliot & Harackiewicz, 1996). After the initial inclusion/exclusion criteria, another set of criteria was enacted. First, only publications that collected data on students were included in the final analysis. Second, publications that did not categorize students into motivational orientations were excluded. Lastly, only studies that investigated STEM students, or were conducted in a STEM class, were included.

The initial search returned 239 journal articles and 391 conference proceedings. After an appraisal process that tested the publications against our inclusion and exclusion criteria, a total of fifty-three studies (forty-six journal articles and seven conference proceedings) were selected for the final review. The final review process included two reviewers conducting a full-text analysis of the documents and meeting regularly to determine emergent themes.

Results

Sixteen studies among all reviewed work associated sex differences with college students' achievement goal orientations. Studies fell into one of three categories: (1) investigation of statistical differences between female and male students' motivational profiles and their association with certain outcome variables, (2) analysis of the statistical differences but failed to report any findings due to non-significant results, and (3) investigation of female students' motivational orientations in STEM fields.

Seven of the sixteen studies in this theme were in this first category. A majority of the studies in this subgroup found statistically significant correlations between biological sex and motivational orientation, targeting students studied in different nations such as Canada (Alrakaf et al., 2015; Simon et al., 2015; Zingaro, 2015) and Thailand (e.g., Koul et al., 2009; Poontej et al., 2013; Songsriwittaya et al., 2010). A significant finding from these studies is that those female students had a higher endorsement of mastery-approach orientation compared to their male counterparts, who were found to have higher rates of performance-based motivation profiles. For instance, one of the studies in this group revealed that female college students possessed mastery-oriented achievement motivation when learning to be an engineer. In contrast, male students focused more on team behavior, which required a more performance-based approach (Fowler et al., 2019).

Five studies investigated sex differences but found non-significant differences between males and females. For example, Johnson & Sinatra (2014) investigated the relationship between students' conceptual change in understanding HIV/AIDS and achievement goal orientations, focusing on differences based on biological sex. Their inferential statistics results showed no differences between female and male participants' pre-and post-test performance and those avoidance orientations were negatively correlated with post-test scores. Therefore, they concluded that neither females nor males had an advantage or disadvantage in their achievement goals when associated with their conceptual change scores. Other studies in this batch showed a similar trend in terms of the non-significant values regarding differences due to biological sex (Dela Rosa & Bernardo, 2013; Roebken, 2007; Muis et al., 2013).

A total of four studies focused solely on female college students' motivational orientations in various STEM fields. One of the interesting aspects of this subgroup was the particular focus on engineering and science. Compared to other studies in the previous subgroups, all the studies in the third batch emphasized engineering and science students' achievement motivation. The main takeaway was that female college students had high self-efficacy, and their choice of mastery goals contributed to their persistence in both engineering and science (Deemer et al., 2016; Jagacinski, 2013; Gatz et al., 2019; Verdin et al., 2015). It should be noted that their achievement motivation was adversely affected by stereotyping and fear of failure.

Discussion

Overall, our systematic review results highlight that the understanding and the reflection of sex differences on STEM-based motivational profiles vary in the existing literature. First, 32% of the reviewed studies did not find statistically significant differences based on biological sex (e.g., Deemer & Smith, 2018; Dela Rosa & Bernardo, 2013; Johnson & Sinatra, 2014). Second, a few studies assumed outright differences based on sex within the engineering context, and these studies commonly discussed certain threats (i.e., stereotyping) negatively impacting female students' achievement motivation (e.g., Deemer et al., 2016; Jagacinski, 2013; Gatz et al., 2019; Verdin et al., 2015). For example, Deemer et al. (2016) examined women's self- and task-approach achievement goals and how gender stereotyping poses a threat to their identification with science. Their results revealed stereotype threat as a factor contributing to a certain degree of reduction in women's achievement motivation studying in STEM majors.

Our systematic review provided several insights focusing on sex differences discussed in the existing literature. One of the main highlights of this review study was that male college students have a higher tendency to possess performance-approach goals in STEM-based learning environments compared to their female counterparts (e.g., Songsriwittaya et at., 2010). This trend can be explained through the change in students' intrinsic motivation, enjoyment, positive affect, deep learning, and persistence. While male students dominate group discussions and contribute to creating a competitive climate in learning settings (an indicator of performance-approach) female students were found to give more attention to learning the content to keep up with their male peers, an indicator of mastery orientation (Koul et al., 2009).

Another important highlight of our systematic review was that the studies that found statistically significant differences between the sexes were mainly from eastern/non-Western cultures. For example, Koul et al. (2009) found that most female Thai students were mastery-oriented, whereas males were performance-oriented. This finding can be associated with the interplay of culture in categorizing students with different motivational profiles. However, review studies conducted with students from a western culture dissimilarly showed that performance-oriented goals contributed to higher achievement levels for female students. This relation was not statistically significant for male students (e.g., Simon et al., 2015). Relatedly, King et al. (1991) associated minor evolution of performance-orientation in females than males due to the stereotype of a desirable female image preferred to be not competitive in eastern cultures. In other words, different motivational motives may vary across biological sex depending on the culture.

Lastly, our systematic review of studies that mainly explored female students' motivational orientations provided mixed results. Besides the fact that the number of studies solely focused on female students' data was comparatively low, only two studies under this theme showed that female students tend to choose mastery goals in an engineering learning context (Gatz et al., 2019; Verdin et al., 2015). This finding can be explained by changing female students' intrinsic motivation, enjoyment, positive affect, deep learning, and persistence in general (Wang & Degol, 2017). Furthermore, half of the studies that looked at female students' motivational profiles concluded that some factors were contributing to female students' low mastery goal orientations (Deemer et al., 2016; Jagacinski, 2013). While Deemer et al. (2016) associated the degree of reduction in female students' achievement motivation in STEM with stereotype threat, Jagacinski (2013) interpreted that female students' experience of the fear of failure and anxiety was triggered by their avoidance goals.

Implications

Our review showed that there is no consensus about motivational orientation differences between males and females within STEM disciplines. While the results are inconclusive, there are still some implications from the findings. First, the academic and professional climates in different cultural learning environments can define whether students become mastery- or performance-oriented. Therefore, we suggest future researchers find and develop culturally appropriate ways to sustain mastery-focused learning environments. Also, researchers may find it prudent to examine the interplay of biological, psychological, and environmental factors for students with different gender preferences. For example, the complex interactions between motivation, socio-cultural environment, and STEM learning can be investigated through advanced statistical models.

A final point of discussion is that researchers who wish to study the interactions of biological sex and motivation should not infer the differences between biological sex and motivational orientations without analyzing this interplay themselves. Without a conclusive finding from our review, we cannot state one way or the other if any such differences exist. Additionally, researchers should point out that differences based on biological sex uncovered during experimentation might be due to cultural expectations and influence, as described above.

Conclusions

We are currently conducting a systematic literature review of achievement goal theory and its use in comprehending undergraduate STEM student motivations. As part of the analysis of our included works, we uncovered five themes in the papers, including differences based on sex. Our main findings suggest the possibility of achievement goals differences, but that culture may be an interplaying factor. Our suggestion moving forward in this space is to not assume one way or the other regarding biological differences and to test for these differences when appropriate to the study. The cultural factors should also be recognized in any finding that may uncover differences. Feedback about the proper presentation of these findings and our suggestions would be greatly appreciated.

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