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Gender and the Social Cure in Undergraduate Physics Students: Physics Identity, Self-efficacy, Belonging, and Wellbeing

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Abstract
The social cure is the concept that strong connections and social bonds are good for wellbeing and physical health. Having strong social support makes hardship easier to cope with. We hypothesize that we could apply the relationship to educational contexts, with a sense of belonging as part of the cohort or community helping students to cope with educational hurdles, resulting in greater wellbeing. We examined the case of women in physics. Previous research has suggested that women in physics classes report a lesser sense of belonging than men. We aimed to replicate this finding and examine how a sense of belonging relates to wellbeing. We surveyed 310 physics students (205 men, 105 women) from a small research-intensive university in the UK. The survey measured students' physics identity, sense of belonging to the physics community, self-efficacy (belief in ability to complete physics-based tasks), and general wellbeing. We found that women and men reported similar levels of belonging and wellbeing, although women reported less physics identity and self-efficacy. Self-efficacy explained a significant fraction of the variance in wellbeing for both men and women. Additionally, belonging explained variance in wellbeing over and above self-efficacy and physics identity for men, but not for women. These results indicate that for men there is a stronger association between belonging and wellbeing, compared to women, but that it does not result in women having an overall lower sense of wellbeing.

Keywords Belonging · Gender · Physics identity · Social cure · Wellbeing

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University can create a number of challenges for students' mental wellbeing (see Hernández-Torrano et al., 2020 for a summary of key challenges). Especially in the early years of study, students face potentially complex academic material whilst still trying to establish new support networks and social groups (Cleary et al., 2011). Students often face problems with their mental health, particularly at the beginning of their academic trajectory (e.g. Macaskill, 2013). In fact, students at university tend to report lower levels of wellbeing than the general population (e.g. Stallman, 2010). As such, universities are placing particular importance on addressing the wellbeing of their students (e.g. Baik et al., 2019; Monk, 2004; Monk & Mahmood, 1999).

One potential way to address problems with student wellbeing is to ensure that students have a solid support network or social group. Known as the "social cure," a sense of belonging as part of a social group has been found to have a positive impact on people's health and wellbeing (e.g. Haslam et al., 2018; Jetten et al., 2009). Therefore, the examination of social aspects of education may be important with regards to improving student mental health outcomes. In particular, under-represented groups in different education contexts — such as women in undergraduate physics classes — may find it harder to feel a sense of belonging with their course or classmates, which could have a negative impact upon their wellbeing.

The focus of the current article is to examine whether the "social cure" might be operating differently for under-and over-represented groups in a discipline. There are numerous factors that contribute to differences in the way in which men and women experience school and undergraduate physics courses. Gender differences have been found in the extent to which students identify with physics as a discipline (Hazari et al., 2010), and in students' belief in their abilities to complete physics-based tasks (self-efficacy, e.g. Nissen & Shemwell, 2016), with women experiencing both lower identification and self-efficacy. These results are concerning as there is evidence from non-physics-based cohorts to suggest that students' wellbeing is associated with both identification with their cohorts (Mavor et al., 2014) and self-efficacy (Phan et al., 2016). As such, the current paper examines the associations between wellbeing and known gender factors in physics (i.e. identity with physics as a discipline, sense of belonging to the cohort, and self-efficacy), as a function of gender.

The Social Cure

The social cure refers to the idea that a sense of belonging is an important predictor of health and wellbeing (e.g. Jetten et al., 2012; Jetten et al., 2009). For example, having a strong sense of identification and a sense of belonging to a social group has shown to be beneficial for patients' acceptance and adaptation to their life after a brain injury (Boden-Albala et al., 2005). Boden-Albala and colleagues (2005) found that patients who had a stroke were significantly less likely to have another stroke in the following five years if they had meaningful social relationships, compared to those that did not have strong social relationships. The social cure has also been associated with fewer mental health problems (e.g. Cruwys et al., 2013). As such, it has been argued that a sense of belonging can be just as important a predictor of health and wellbeing as diet and exercise (Jetten et al., 2009).

Applied to physics education, the social cure may *not* be benefitting groups that are under-represented and do not feel like they belong as part of their course. Disparity in a sense of belonging between men and women in physics (see Seyranian et al., 2018) could result in women experiencing comparatively lower wellbeing. Conversely, fostering a sense of belonging in under-represented students could positively impact their wellbeing. It is likely that students who feel as if they belong will perceive their social connectedness to be richer and may lead the student to feel they have more positive relationships with others. For example, Walton and Cohen (2011) introduced an intervention for social belonging whereby freshman students read passages written by older students which outlined the struggles that students face at university, highlighting how these struggles were normal and could be overcome. The task promotes a sense that the student still belonged as part of the department, even if they were facing challenges. Walton and Cohen found that completing the task disproportionately improved African American students' grades, general health, and subjective happiness compared to White students. These results provide initial evidence that increasing belonging in under-represented groups may allow these students to feel the benefits of the social cure.

A sense of belonging may not only give students a greater sense of social support but having a greater sense of identity as part of a group can help protect minority groups against prejudice. For example, Branscombe et al. (1999) found that African American participants who felt like they had been discriminated against reported lower levels of wellbeing. However, for the participants that identified strongly as an African American, the impact of feeling discriminated against had a weaker impact upon their wellbeing, compared to participants that did not strongly identify as an African American. Therefore, it is possible that greater identity and a sense of belonging as part of a social group may also protect minority groups against prejudice and discrimination; potentially preserving wellbeing. These results highlight the importance of the creation of a sense of belonging and identity for under-represented groups that can be discriminated against in the higher education setting.

Self-efficacy and Student Wellbeing

The social cure explains why belonging and identification with social groups may be associated with wellbeing, but they are not the only predictors of wellbeing. Self-efficacy is also associated with wellbeing. Karademas (2006) examined aspects of self-efficacy, optimism, perceived social support and participants' sense of life satisfaction. They created a path model with the different factors and found that resilience self-efficacy, (i.e. the belief that one will be able to cope with the negative aspects of a stressful experience), and the participant's reported emotional social support, both predicted the self-reported levels of optimism. The level of reported optimism predicted participants' satisfaction with life. Furthermore, participants' resilience self-efficacy also directly predicted their satisfaction with life. Whilst resilience as part of self-efficacy is only a part of the broader measure of self-efficacy we are using in the current paper, Karademas's (2006) findings may provide some evidence to suggest that self-efficacy is related to wellbeing.

A more direct examination of the impact of self-efficacy in an academic context was conducted by Phan et al. (2016). They surveyed a number of secondary school students in a mathematics class to measure their self-efficacy, wellbeing, and engagement in mathematics learning. They also measured academic achievement via a quiz and the assessment at the end of the school term. Using structural equation modelling, Phan and colleagues examined the relationship between these variables. They found that academic self-efficacy was associated with students' self-reported levels of wellbeing. Similarly, the greater the student's academic self-efficacy, the more engagement with the mathematics learning reported. Students' self-reported academic self-efficacy was associated with the academic grades that they received in the quiz and the test at the end of the year. The results from Phan and colleagues' (2016) study provide further, and more substantial, evidence to support the hypothesis that students' self-efficacy may also be associated with wellbeing.

The Physics Context

The example of women in physics was chosen as the under-representation of women in the field of physics is well-documented and consistent across years. It also allowed us to collect data within a very specific context, rather than a multidisciplinary study where the problems that face students may be varied and unclear.

There are also clear barriers to women in physics which can impede their progression. Women in the field sometimes report not feeling like they identify with the discipline of physics (Hazari et al., 2010), that they can be assigned student roles that are gendered, such as secretarial roles (Doucette et al., 2020), and the awareness of gender stereotypes of women in physics can form negative self-perceptions (e.g. Marchand & Taasoobshirazi, 2013). As such, women face several barriers to their progression in physics, many of which lead to more women exiting the field.

It may also be the case that the women in physics have a lower sense of belonging, compared to men. It is possible that students of under-represented groups in education have a lesser sense of belonging, due to not having the characteristics of the prototypical student in the class (e.g. for women in STEM education, see Lewis et al., 2017; Seyranian et al., 2018). Furthermore, a lack of sense of belonging may be related to wellbeing. For example, Seyranian and colleagues (2018) examined gender differences in physics identity, belonging, grades, and perceptions of flourishing on the physics course in a sample of college students enrolled in an introductory calculus-based physics course. They found that men reported greater physics identity and marginally greater belonging as part of the physics course, compared to women. Students that identified with physics to a greater extent achieved better grades and flourished more on the course. Flourishing has a number of overlapping features with wellbeing, with Diener and colleagues (2010) defining flourishing as having meaning and purpose in life, having rewarding social relationships, self-acceptance, being optimistic about the future, and being respected by others. As such, Seyranian and colleagues' (2018) results may provide initial evidence that men in physics may benefit from the social cure more than women.

In the current study, we focus on physics identity, a sense of belonging to the physics community, and physics self-efficacy. The decision to examine these three variables are twofold. Firstly, physics identity (Hazari et al., 2010; Kalender et al., 2019a), self-efficacy (Nissen & Shemwell, 2016), and belonging (Seyranian et al., 2018) have all been identified as perceptions that can vary by gender in physics. As such, their investigation may shed light on gender differences in the field. Secondly, as outlined above, each of these variables have been associated with wellbeing (see Mavor et al., 2014; Phan et al., 2016; Seyranian et al., 2018).

The Present Research

The current study examines how the social cure might operate in a university undergraduate physics context, and whether it occurs similarly for men (who are in the majority group) and women. Firstly, it is unclear whether a sense of belonging to the physics community is associated with better wellbeing in physics undergraduate students. Secondly, it is unclear whether wellbeing is associated with belonging, above and beyond other gendered differences in physics students' experiences such as self-efficacy and identification with physics as a subject.

We designed surveys to measure all these key factors within the same group of undergraduate physics students. Based on the previous research described above, we predict that physics identity, self-efficacy, and belonging as part of the physics community will be associated with student wellbeing, with women reporting lower levels of all quantities, as they are the under-represented group in this context (e.g. Seyranian et al., 2018). Moreover, we hypothesize that the strength of association between, a sense of belonging to the physics community, and wellbeing will be weaker for women, compared to men who are benefitting more from the social cure.

Methods

The Sample and Data Collection

Students studying for degrees in physics were recruited from a small, research-intensive university in the UK. Surveys were administered at the start of an academic session across all levels of the degree programme (from introductory level 1 to the integrated Masters level 5). For students in level 1, it means that their response to some of the survey questions will be understood to refer to their experience in advanced level school physics.

A total of 310 completed student surveys were collected from physics major students who identified as men or women. Surveys completed by the small number of students who did not identify as men or women were not considered further, as they represented too small a sample for analysis and also raised identifiability concerns. The 310 students represent around 80% of all physics majors at the University. Of these students, 26.1% were in the first level, 24.2% in the second level, 18.4% in the third level, 14.8% in the fourth level, and 16.5% in the fifth (integrated

Master's) level. The sample consisted of 205 men and 105 women (34% women). The undergraduate student population was around 30% women in the years when the data was collected, which sits a little above the UK national average for physics majors of around 26% over the same time period. Gender was not included in the survey itself (to downplay self-awareness of gender during completion). Gender was added based on student records before the data was anonymised. A breakdown of the sample by Level and gender is shown in Table 1. A power analysis based on the gender belonging effects reported in Seyranian and colleagues' (2018; $d=0.309$) study suggested we needed a sample of 176 students (88 men and 88 women). Thus, the sample size when collapsed across levels seems sufficient for further analysis. This study received appropriate ethical approval. The institution in which the study was conducted gave their approval, and informed consent was obtained from all participants before they completed the study.

Measures

Identification with Physics

To examine the extent to which students identified with physics we used a single item from the Physics Identity Survey (Hazari et al., 2010). The item read: "Do you see yourself as a physics person?". This item has been used in a plethora of studies (e.g. Godwin et al., 2016; Kalender et al., 2019a, 2019b), and is generally considered to be a good measure of general identification with physics (Potvin & Hazari, 2013). Physics identity was measured on a scale between 1 (not at all) and 7 (very much so).

Belonging

To measure students' sense of belonging we used the Membership Subscale of Good et al. (2012) Sense of Belonging Scale. The Subscale consisted of four items (Cronbach's $\alpha=0.945$). These items were: "When I am in a physics setting (such as a workshop, lab or tutorial) … I feel that I belong to the physics community," "…I consider myself a member of the physics community," "…I consider myself a member of the physics world," and "…I feel a connection with the physics community". These items were measured on a scale between 1 (strongly disagree) and 8 (strongly agree).

Table 1 The breakdown of surveys (310 total, 205 men, and 105 women) collected by level of the degree programme and gender from level 1 (introductory) to level 5 (integrated Masters)

Level	*N*	Men	Women
Level 1	81	72.8%	27.2%
Level 2	75	60.0%	40.0%
Level 3	57	78.9%	21.1%
Level 4	46	58.7%	41.3%
Level 5	51	56.9%	43.1%

Self-efficacy

Students' self-efficacy was measured using four items from the Physics Self-efficacy Questionnaire (Lindstrøm & Sharma, 2011). The items were the following: "I generally manage to solve difficult physics problems if I try hard enough," "I know I can stick to my aims and accomplish my goals in physics," "I will remain calm in my physics exam because I know I will have the knowledge to solve the problems," and "I know I can pass the physics exam if I put in enough work during the semester". Self-efficacy was measured on a scale between 1 (strongly disagree) and 5 (strongly agree). The scale had good reliability in our sample (Cronbach's $\alpha = 0.748$).

Wellbeing

Wellbeing was measured using the GP-CORE survey (Evans et al., 2005). This is a 14-item scale (Cronbach's $\alpha = 0.749$). The GP-CORE is used to assess wellbeing in non-clinical student populations. With a time-context defined as "Over the last week…" some example items were: "…I have felt able to cope when things go wrong," "…I have felt warmth or affection for someone," and "…I have felt optimistic about my future". Wellbeing was measured on a scale between 1 (not at all) and 5 (most or all of the time).

Analysis Plan

Examination of the Q-Q plots suggested the data was normally distributed. Firstly, we examined potential gender differences between men and women for each of the four measures outlined above. We ran a series of independent samples t-test to compare the differences between the means of the measures for men and women. Secondly, we ran a series of hierarchical regression analyses to see how much variance might be explained by belonging, physics identity, and self-efficacy collectively.

Missing responses accounted for 0.22% of the total dataset. To account for the missing data, we used expectation–maximization item replacement.

Results

The bivariate correlations between variables for men and women separately can be seen in Table 2. Table 2 showed that all of the variables were significantly positively correlated with each other, with correlations of moderate strength ($r > 0.3$) between self-efficacy and the other variables and between physics identity and belonging, and weak correlations ($r < 0.3$) between identity and wellbeing. The correlations between belonging and wellbeing were weak for women but of moderate strength for men.

An examination of the means via independent samples t-test showed significant differences between men and women with regards to physics identity and self-efficacy, but not belonging or wellbeing (see Table 3). The effect sizes for the significant differences were relatively small (Cohen's $d = 0.32$ for self-efficacy and $d = 0.23$ for physics identity).

Table 2 Pearson's correlations (r) between variables for the responses from women (top, $N = 105$) and men (bottom, $N = 205$). "ID" represents physics identity

	Self-efficacy	ID	Belonging	Wellbeing
Women				
Self-efficacy	1	.416**	.471**	.449**
ID		1	.611**	.212*
Belonging	1			.249*
Wellbeing				1
Men				
Self-efficacy	1	.399**	.429**	.411**
ID		1	.555**	.186**
Belonging			1	.380**
Wellbeing				1

*$p < .05$, **$p < .01$

To examine the relationships between the variables we ran two hierarchical multiple linear regressions, one for the men and one for the women. These models used physics identity, self-efficacy, and belonging as predictor variables and wellbeing as the outcome variable. Given the differences seen in the correlations between belonging and wellbeing for men and women in Table 2 and our interest in the social cure link, in both models, self-efficacy and physics identity were included in step 1, and belonging was then added in step 2, to see whether belonging explained variance in wellbeing beyond the variance explained by physics identity and self-efficacy (the means and standard deviations for belonging by gender and level can be seen in Table 3). In what follows, when we use the word "predict" we mean it in the purely statistical sense, where predict refers to the variance predicted in an outcome variable by a predictor variable. As we use it, "predict" does not imply causation, rather the presented analysis is correlational. Firstly, we checked the linearity of the relationships between the variables with a scattermatrix (Fig. 1). The scattermatrix revealed that the relationships were sufficiently linear to proceed.

For men, the simultaneous model, including self-efficacy and physics identity together, was significantly associated with wellbeing, $F(2202) = 20.576$, $p < 0.001$. These two variables explained 16.9% of the variance in wellbeing. However,

Table 3 Means, standard deviations, F-statistics, and p-values for analysis between men ($N = 205$) and women ($N = 105$) for the four variables: self-efficacy, physics identity (ID), belonging, and wellbeing

	M_{Men}	SD_{Men}	M_{women}	SD_{women}	t-statistic (df = 1308)	p-value
Self-efficacy	3.989	.612	3.802	.590	2.59	.010*
ID	5.264	1.421	4.928	1.357	2.00	.046*
Belonging	5.255	1.463	5.270	1.520	− .09	.931
Wellbeing	2.863	.456	2.878	.411	− .29	.769

Please note that these variables measured on different scales. As such, means cannot be compared directly between variables. Running these analyses without the estimation maximization data replacement did not impact upon the significance of the results. *$p < .05$

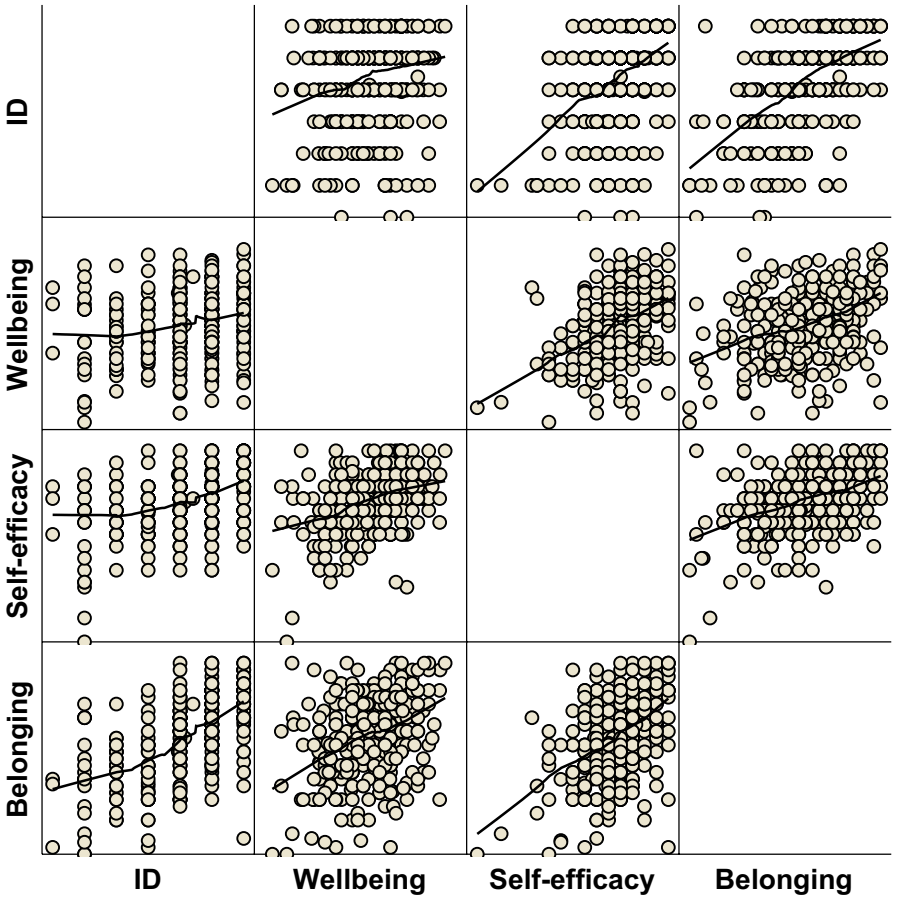

Fig. 1 A scattermatrix with all variables plotted against one another for men and women combined. Loess lines have been fitted to represent the linearity of the relationships The Loess lines are progressive averages, which provides a strong approximation of the relationship between two variables (a more accurate representation of the linearity of a relationship than a simple line of best fit)

further examination of the coefficients for self-efficacy and identity revealed that physics identity was not significantly associated with wellbeing ($\beta = 0.027$, $p = 0.705$), however self-efficacy was significantly associated with wellbeing ($\beta = 0.400$, $p < 0.001$). We then added belonging to the model. The addition of belonging significantly improved the model, $F_{\text{change}}(1201) = 15.250$, $p < 0.001$. Belonging increased the proportion of variance explained ($R^2_{\text{change}} = 0.059$), with the overall variance in wellbeing being explained by the three variables increasing to 22.8%. The addition of belonging also changed the standardized regression coefficients; however, physics identity still was not significantly associated with wellbeing ($\beta = -0.111$, $p = 0.146$). Self-efficacy ($\beta = 0.325$, $p < 0.001$) and belonging ($\beta = 0.302$, $p < 0.001$) were both significantly associated with wellbeing when belonging was added in the second step.

For women, the model including self-efficacy and physics identity together was significantly related to wellbeing, $F(2102) = 12.914$, $p < 0.001$. These two variables explained 20.2% of variance in wellbeing. As with men, the examination of the standardized regression coefficients of the variables separately revealed that physics identity did not significantly predict variance in wellbeing ($\beta = 0.031$, $p = 0.747$) and self-efficacy was significantly associated with wellbeing ($\beta = 0.436$, $p < 0.001$). Unlike for men, the addition of belonging did not significantly improve the model, $F_{\text{change}}(1101) = 0.131$, $p = 0.718$. Belonging failed to significantly increase the proportion of variance explained ($R^2_{\text{change}} = 0.001$), with the overall variance in wellbeing being explained by the three variables increasing to just 20.3%. Similarly, the addition of belonging slightly altered the standardized regression coefficients, but neither physics identity ($\beta = 0.010$, $p = 0.930$) nor belonging ($\beta = 0.043$, $p = 0.718$) were significantly associated with wellbeing. Self-efficacy alone significantly explained the variance in wellbeing ($\beta = 0.424$, $p < 0.001$).

The examination of the correlations (Table 2) suggests that the relationship between physics identity and wellbeing and belonging and wellbeing is more similar in size for the women in our sample than it is for the men. As such, we wanted to test whether there were significant differences between the two correlations for men and women. We tested the difference between the two dependent correlation using Lee and Preacher's (2013; http://quantpsy.org/corrtest/corrtest2.htm) "calculation for the test of the difference between two dependent correlations" software. The results revealed that there were no significant differences between the correlations for physics identity and wellbeing ($r = 0.212$) and belonging and wellbeing ($r = 0.249$) for women ($p = 0.661$). Conversely, the correlations for physics identity and wellbeing ($r = 0.186$) and belonging and wellbeing ($r = 0.380$) were significantly different from one another for men ($p = 0.002$).

Discussion

In contrast to our hypothesis, the results of the current study found no significant gender differences in belonging or wellbeing between undergraduate physics men and women. However, we saw significant differences emerge between men and women with regards to reported physics identity and sense of self-efficacy. Moreover, our results suggested that, for both men and women, physics identity was not significantly associated with wellbeing when included in a model with self-efficacy, while belonging (controlling for identity and self-efficacy) was significantly associated with wellbeing in men but not in women. Our final analysis suggested that the size of the correlation between physics identity and wellbeing was roughly similar in size to the correlation between belonging and wellbeing for women, but for men there was a significant difference between the size of these correlations, with a stronger correlation between belonging and wellbeing than between identity and wellbeing. The difference in the size of the correlation for men, but not for women may point to there being a difference in the way in which physics identity and belonging are perceived, or how these constructs relate to wellbeing, between men and women in physics undergraduate courses.

The disparity in both physics identity (e.g. Hazari et al., 2010, 2013; Seyranian et al., 2018) and self-efficacy (e.g. Nissen, 2019; Nissen & Shemwell, 2016) between men and women studying physics is well-documented in the literature. Our results conceptually replicate these findings, demonstrating that men had significantly greater self-efficacy and identification with physics than women. Having high self-efficacy and identifying with your discipline of study have been associated with beneficial academic outcomes, such as better academic performance (e.g. Lane et al., 2004; Seyranian et al., 2018) and taking a more immersive approach to learning (e.g. Smyth et al., 2017; Smyth et al., 2015). Moreover, identification with physics has been associated with retention of students in physics (e.g. Hazari et al., 2010), just as identification with one's discipline more generally has been found to impact on intention to continue to study in the area (Platow et al., 2013). The gender differences in physics identity and self-efficacy in the current study are in line with previous research, and may have an indirect effect on women's academic outcomes.

Unlike self-efficacy and physics identity, no significant gender differences were found for belonging or wellbeing. With regards to belonging, previous studies found inconsistent effects. While Seyranian and colleagues' (2018) found only marginal differences between men and women at the introductory physics level with regards to belonging ($p = 0.09$), and we found no difference in a sample of students across all levels, Stout et al. (2013) did find strong significant differences between men and women at the introductory level with regards to belonging. Therefore, the robustness of the gender differences in belonging as part of a physics community seems unclear and may be context dependent. Further research is required to ascertain under what contexts these gender differences in belonging occur.

Despite there being no significant gender differences with regards to belonging in this study, there was a different pattern of results with regards to the relationship between belonging and wellbeing for men and women. For men, there was a significant positive correlation and association in the regression model between belonging and wellbeing. Conversely, for women, despite there being a significant positive correlation between belonging and wellbeing, the regression pathway between belonging and wellbeing was not significant when physics identity and self-efficacy were included in the model. In the current study, the relationship between belonging in physics and wellbeing is stronger for men than for women and belonging also emerges as a significant additional predictor of wellbeing over-and-above physics identity and self-efficacy. The result suggests that men's sense of belonging predicted variance in their wellbeing, over-and-above the effects of physics identity and self-efficacy. We reemphasize that we use the term "predict" in a purely statistical sense of explaining variance of an outcome variable, and our analyses indicate association rather than causation. These findings lay the groundwork for future studies to causally examine these factors, to investigate whether men's belonging in the physics community causally impacts their wellbeing.

The comparison of the two dependent correlations corroborated the regression analyses, suggesting that the difference between the correlations for physics identity with wellbeing and belonging with wellbeing was significant for men, but not for women. This result could point to gender differences in the way in which physics identity and belonging are understood. Supporting the regression analysis, it may be

that for women, physics identity and belonging have similar associations with well-being, whereas for men, the higher correlation between belonging and wellbeing suggests the role of some additional process that is related to belonging for men but not for women. Therefore, in spite of the fact men and women do not report different mean levels of belonging and wellbeing, the relationship between belonging and wellbeing might be understood differently. Future research may be able to examine this disparity in the relationships more directly. Examination of the disparity in the relationships could give an insight as to how students' experience of self-efficacy, belonging, and identity might vary by gender, which could inform the future development of targeted belonging and wellbeing interventions.

Future Directions

An interesting direction for future research would be to examine the causal impact of belonging on wellbeing in different educational contexts. Belonging interventions, such as the one created by Walton and Cohen (2011), may clarify the relationship between belonging and academic outcomes. Walton and Cohen (2011) demonstrated that having freshman students read excerpts from older students describing their challenging experiences, and how these were often a natural part of the transition to higher education, increased the grade point average of African American students. Recently, Binning and colleagues (2020) examined a similar intervention to Walton and Cohen (2011) in a sample of women in a basic physics course for engineers. They found that the belonging intervention resulted in a marked improvement in academic performance for the women on the course. Replicating the intervention with wellbeing (or subjective happiness as used by Walton and Cohen) examined as the outcome variable may shed light on the relationship between belonging and wellbeing. A replication would be a very useful future direction as it would add clarity to whether the belonging intervention increases the grades of under-represented groups only or whether it can also spark the social cure effect in under-represented groups in education settings where (pre-intervention) the association between belonging and wellbeing is weak, as in the current study.

We predicted that women, as an under-represented group in physics, would experience lesser belonging and as a result would not receive the benefit of an association between belonging as part of the physics community and wellbeing. The results contradicted our hypothesis, with men and women reporting similar levels of belonging and wellbeing. It is likely, given the large belonging differences found in previous studies (e.g. Stout et al., 2013), that whether differences emerge between a represented and under-represented educational group is context dependent (see Hazari et al., 2020). However, it may be of interest to investigate if a significant link between belonging and wellbeing is common amongst under-represented groups. It is possible that, like in our study, under-represented groups will report similar belonging but that belonging is not associated with wellbeing, over-and-above other relevant factors. As such, it would be an interesting future direction to examine to what extent the link between belonging as part of an educational group and wellbeing is context dependent.

Summary

The results of the current study corroborated prior research that suggests there are gender differences with regards to self-efficacy and physics identity, with men reporting greater levels than women (e.g. Hazari et al., 2010; Nissen & Shemwell, 2016). However, no gender differences emerged with regards to belonging and well-being. Furthermore, although belonging is correlated with wellbeing for both men and women, the association does not hold for women when controlling for physics identity and self-efficacy. We also found that there were significant differences in the strength of the correlations between belonging and wellbeing and identity and wellbeing for women, but not for men. These findings open important pathways for future theory development, but also new directions for interventions aimed at reducing these more subtle gendered pathways to belonging.

Data Transparency and Availability Statement

Given the nature of the data (e.g. the use of student numbers to match data and the self-reported wellbeing scores) the data for this study will not be shared on a public repository. This is solely to protect the anonymity of students involved. Given the sensitive nature of the data, the data will not be made available to preserve the anonymity of the participants.

Declarations

Competing Interests The authors declare no competing interests.

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