Social ties, mental well-being and academic self-regulation. Exploring effects through Structural Equation Modeling.

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Social ties, mental well-being, and self-regulated learning in engineering education: exploring effects through Structural Equation Modeling

Abstract

A long tradition of studies in both psychology and sociology has shown that social ties have positive effects on mental well-being of both the population in general and in educational contexts in particular. Specifically, researchers argue that mental well-being is systematically related to students' academic self-regulation. However, it is not clear how these three constructs are related, and what direct and indirect effects may exist from social ties to academic self-regulation. In the context of engineering education, this question is especially relevant because the literature has documented gaps in the formation of ties of minority social groups -such as women or ethnic groups- which could have effects on their mental well-being and their academic self-regulation. This work proposes a theoretical model in which the sense of belonging and sense of mattering have effects on mental well-being, while mental well-being has effects on students' academic self-regulation. This theoretical model was tested by using structural equation modeling, with data from an online survey applied to 1,872 engineering undergraduate students during the first semester of 2022. The main fit indicators of the model with the empirical data satisfactorily meet the cut-off criteria established (RMSEA=0.041; SRMR=0.038; CFI=0.998; TLI=0.998). The central effects proposed in the resulting theoretical model are statistically significant, both from the sense of belonging and mattering towards mental well-being, and from it towards academic self-regulation. This implies that there is an indirect effect from the sense of belonging towards academic self-regulation.

Keywords: Sense of belonging, Sense of mattering, well-being, self-regulated learning, Engineering education

Introduction

In higher education, attention to students' mental health has grown in recent years [1]. In engineering education, some work has begun to emerge on student well-being [2], but there is still much work to be done. The role of stress within engineering culture has not been fully explored in the literature [3], despite the stress experienced by engineering students [3]. This particularly affects women and other underrepresented groups in engineering degrees, who experience more difficulties to feel welcome in college settings as future engineers [4].
Prior work has shown that several factors can influence an individual's well-being and mental health, including social factors, motivation, and academic discipline, among others [1]. Other concepts that have been explored are self-sufficiency, sense of belonging, and social self-efficacy [1]. Studies have also examined the relationships among self-reported stress, anxiety, and depression; engineering identity; and perceptions of inclusion of undergraduate engineering students [3].

In this context, it has become critical to determine the predictive factors of student well-being and how well-being affects academic performance in engineering degrees [2]. Identifying how social ties and well-being may affect engagement and academic performance is an important research endeavor, since an answer to such question may shed light on which actions can be

taken by institutions to create nurturing learning environments. These relationships, however, have not been fully established [2]. Another relevant question is the relationship between academic self-efficacy and positive psychological well-being, seeking to clarify the causal chain between academic performance and well-being [5].

This study tests a theoretical model that explains the relationship among sense of belonging, sense of mattering and mental well-being, along with the relationship between mental well-being and students' academic self-regulation. Further implications for research and practice are discussed to support subgroups of engineering students.

Theoretical framework

Mental well-being

There are multiple approaches to what mental well-being is. There is the notion of subjective well-being [6], psychological well-being [7], [8], and mental health [9], to mention a few. Despite the different denominations, there is a relative consensus that the notion of well-being includes subjective and psychological aspects [10].

Clarke et al. [10] describe mental well-being as a sustainable positive mental state that encompasses two dimensions: the hedonic, which consists of positive feelings such as happiness, calm, or enthusiasm; and eudaimonic, which includes cognitive elements and the development of autonomy, self-acceptance, positive relationships with others, a sense of belonging, and a sense of purpose [11], [12].

An interesting aspect of the conceptualization of mental well-being proposed by Clarke et al. [10] is that the social ties are presented in two ways: sense of belonging and positive relationships with others. In this way, social ties are considered part of the very definition of mental well-being. However, it seems an oversimplification to understand social ties simply as an aspect of mental well-being. Rather, it seems more reasonable to consider them two ontologically different, albeit strongly related, elements [13].

Sense of belonging and sense of mattering

One of the foundational works of sociology as a science was the study of suicide carried out by Durkheim [14], where he concluded that one of the causes of this phenomenon would be the fractures of social integration mediated both by culture –e.g., the identity shared by an us– as well as by the mechanisms of cooperation and interdependence among people.

In the context of our study, two different concepts are used to observe social ties: a sense of belonging and a sense of mattering. The discussion about the sense of belonging could be traced back to classic works [15] – [17], although a more current definition is the one presented by Good et al. [18], where it is understood as the personal belief that one is an accepted member of a community, whose presence and contributions are valued. This definition could be complemented by the feeling that an identity is shared with that community, an element widely present both in the aforementioned article by Good et al. [18], and in more recent works [19].

The notion of sense of mattering, on the other hand, investigates the ties created in micro social interactions. Rosenberg and McCullough [20] defined it as the feeling that others depend on us, in addition to being interested and concerned about us, our destiny and experiences. Despite the fact that this concept has been less addressed in research than the sense of belonging, some interest has arisen in studying the sense of mattering in educational contexts because it allows for a more complex vision of the experience of marginalized groups, which do not necessarily feel that they belong to a community, but they can still develop meaningful ties with their environment [21] such as African-American [22] or Latino students in the U.S. [23], or female engineering students [24].

In this way it is understood that mental well-being and social ties are different but related aspects of reality. Now how, specifically, are they related? It is hypothesized that there is an influence from social ties towards well-being, and over the years evidence has been accumulating in this regard from various approaches.

From the notion of sense of mattering, Rosenberg and McCullough [20] observed that there was a relationship between low levels of sense of mattering and high levels of depression, which has been confirmed by more recent studies in the context of university students [25], [26][27], [28]. In the meanwhile, studies that have worked from the sense of belonging construct have found evidence that students' sense of belonging contributes to reducing symptoms of depression and other mental health problems [29]–[31]. In this way, following Flett's argument [32] it is understood that both the sense of mattering and the sense of belonging influence mental well-being to the extent that they can attenuate the impact that life stressors have on the people's lives.

Relationship between sense of belonging, sense of mattering, and self-regulated learning

In the context of university education, social ties have been studied in relation to motivation to learn and student retention [33], absenteeism [34], stress and emotional regulation [35]. Following Pintrich's [36] argument, we assume that the notion of academic self-regulation would be the key factor that mediates between psychological and contextual aspects of students and their academic performance. For this reason, the decision was made to incorporate academic self-regulation into the study.

Pintrich [36, p. 387] understands as academic self-regulation, the potential ability to "monitor, control, and regulate certain aspects of their own cognition, motivation, and behavior as well as some features of their environments". This perspective assumes that learning is an active process, where the subjects establish their own meanings, goals, and strategies. It also assumes that there is some criterion or goal against which to assess whether or not modifications are needed in the learning strategy.

Pintrich's proposal [31] understands that academic self-regulation has cognitive, motivational, contextual, and behavioral dimensions. This work focuses on this last dimension because it facilitates the evaluation of manifest indicators, which are easier to measure. Behavioral self-regulation consists of individuals' attempts to control their own behavior, distributing the effort invested in a course, managing study and rest time, organizing their work environment [36], [37].

Rodríguez et al. [38] made a systematic review of the studies that analyzed the relationship between student well-being and self-regulated learning. They found that some self-regulation deficits are significantly associated with different dimensions of student well-being. However, it is an open debate how to interpret this relationship. Some authors argue that the correlation between academic self-regulation and well-being would be explained by emotional self-regulation [38]–[41]. Despite the fact that this effect seems hardly debatable, other works have argued that emotional self-regulation requires effort, which is why it operates as a resource that is gradually depleted in the face of the accumulation of self-control demands, producing fatigue [42]. Faced with this, the hypothesis has been proposed that social support can be a protective factor in stressful situations and the accumulation of self-regulation demands [43], [44], which has also been observed in academic self-regulation in university contexts [45], so there should also be an effect originating in well-being and spreading towards academic self-regulation.
In conclusion, based on the discussion in the literature, it is proposed as a hypothesis that the complex combination of a sense of belonging and a sense of mattering would have effects on mental well-being and that this, in turn, has effects on the self-regulated learning of the students. This implies that the effect of social ties on academic self-regulation is indirect and is mediated by the mental well-being of students.

Understanding the causal relationships among these concepts can contribute to the design of interventions to support mental well-being of students and the way in which they manage their learning processes. This is especially relevant in the context of engineering education, where studies have already documented disparities in the sense of belonging of female students [4], first generation university students [46] and other underrepresented minorities [47].

Methods

The objective of this study is to test the hypothesis proposed in the theoretical discussion to explain the relationships between a sense of belonging, a sense of mattering, mental well-being, and self-regulated learning. For this, a quantitative study was developed through a survey applied to undergraduate students in an engineering school. In this survey, four scales were applied with the purpose of measuring each one of the discussed constructs.

For the sense of belonging, the scale proposed by Good et al. [18] was adapted from the area of mathematics to engineering, in addition to being translated into Spanish. From the complete scale, two subscales of the complete instrument were selected: membership and acceptance (positive), leaving out acceptance (reverse coded), affect (positive), affect (reverse coded), trust and desire to fade, which point to aspects which were not relevant for this study. The items on this scale are 5-point Likert questions that measure the level of agreement with a series of statements about whether the respondents feel they belong to the engineering community, and whether they feel accepted and respected in the community.

Table 1: Sense of belonging scale (5-point Likert scale of agreement)

Subscale	**Items**
Membership	I feel that I belong to the engineering community
	I consider myself a member of the engineering world
	I feel that I am part of the engineering community

Subscale	Items
Acceptance	I feel a connection to the engineering community
	I feel accepted
	I feel respected
	I feel valued
	I feel appreciated

To measure the sense of mattering, the scale of Hilliger et al. [24] was used to ask students about their level of agreement with a series of related statements regarding the level of concern of different peer and institutional actors in a hypothetical situation where the respondent did not return to university. This 4-point Likert scale and it is built on two dimensions – classroom mattering (classmates, friends, and professors), and institutional mattering (professors, managers, student services and staff members).

Table 2: Sense of mattering scale (4-point Likert scale of agreement)

Subscale	Items
Classroom mattering	My classmates from my major will miss me
	My friends from the university will miss me
Institutional mattering	At least one teacher will be concerned about my situation
	At least one person from student services will be concerned about my situation
	At least one member of the career/program management team will be concerned about my situation
	At least one staff member will be concerned about my situation

The short version of the Warwick-Edinburgh Mental Wellbeing Scale (known as SWEMWBS) was used to measure mental well-being (see Table 3), which was proposed by Clarke et al. [10] and validated by Bass et al. [48]. This version consists of seven ordinal items that investigate the frequency of different mental well-being indicators of the respondent during the last two weeks, related to the two dimensions of mental well-being considered by Clarke et al. [10]: hedonic (subjective) and eudaimonic (cognition and autonomy). Of the seven original items, "I have felt close to other people" was excluded from the model because it could contribute to overestimating the relationships between a sense of belonging, sense of mattering, and mental well-being.

Table 3: SWEMWS (7-Point Likert Scale of frequency from ‘Never’ to ‘Always’)

Subscale	Item | In last two weeks…
Hedonic	I have felt optimistic about the future
	I have felt relaxed
	I have felt useful
Eudaimonic	I have coped well with the problems
	I have been able to think clearly
	I have been able to make my own decisions

Finally, academic self-regulation was measured by using an adaptation of the MSLQ [49], [50] for university students in Chile [51]. From this version, a subscale was selected according to its relevance for the objectives of this study: time and study environment management (TSEM). In this way, only one of its dimensions is considered from the complex construct of self-regulated learning. Table 4 shows the items of the sub-scale used to measure time management and study environment. Some of the items are formulated in a negative wording, so their scores were reverse coded to facilitate the interpretation of the results (being high scores an indicator of better time management skills).

Table 4: MSLQ, self-regulated learning sub-scale (7-point Likert scale of agreement)

Subscale	**Item**
Time and study environment management	I find it hard to stick to a study schedule. (–)
	I make good use of my study time.
	During class time I often miss important points because I'm thinking of other things. (–)
	I often find that I don't spend much time on studying because of other activities. (–)
	I have a regular place set aside for studying.

Study context

This study was conducted in an engineering school of a Latin American university which is highly selective in its admission exams. In this school, there is a universe of about 4,600 undergraduate students, distributed in different specialty majors (Operations Research, Software Engineering, Electrical Engineering, Mechanical Engineering, among others). Every admission cohort consists of between 800 and 850 students and approximately 35% are women. The duration of the program is five years officially, but many students take six or seven years to finish their studies.

The survey was applied online and voluntarily to 1,766 undergraduate students during the first semester of 2022 (62.7% male, 35.2% female and 2.1% non-binary or prefer not to answer; 29.6% from a region different from campus), considering all majors and admission cohorts between 2016 and 2022.

Table 5: Demographic description of study participants

Admission cohort	***n***	**%**
2022	345	19.5
2021	342	19.4
2020	297	16.8
2019	251	14.2
2018	238	13.5
2017	171	9.7
2016 or earlier	122	6.9
Gender		
Female	622	35.2
Male	1108	62.7

Admission cohort	*n*	%
Non-binary	14	0.8
I prefer not to answer	22	1.3
Comes from a different region than campus		29.6
Yes	523	29.6
No	1243	70.4

Data analysis

To achieve the research objective of testing the proposed model, the most pertinent analysis technique is Structural Equation Modeling [52], a technique that consists of a combination of factor analysis and regression models. This makes it possible to study complex theoretical concepts, difficult to measure, by estimating them as latent variables to a set of observed variables, and then modeling the effects that exist between these latent variables. The model provides a series of fit indexes between the proposed model and the empirical data [53]. Hu and Bentler [54] suggest acceptance criteria for a good fit: RMSEA should be < .06; SRMR <.08; CFI >.95 and TLI >.90. Data were analyzed using the Lavaan package [55] which allows the estimation of structural equation models in R [56], using Maximum Likelihood as fitting procedure with specific adaptations for ordinal items such as the ones in the scales used in this study.

Proposed model

Considering that each subscale measures a different concept, it is represented by a different latent variable. However, as aforementioned, the way that mental well-being is theoretically defined to include closeness with other people within the hedonic dimension, this could cause the effect from the latent dimensions of the sense of mattering and sense of belonging to be overestimated. Therefore –as previously detailed– it was decided to exclude this item from the model.

Figure 1 presents the study hypothesis represented in the form of a theoretical model. According to this model, acceptance is explained by classroom mattering, institutional mattering and membership. In turn, this would have effects on the two dimensions of well-being (hedonic and eudaimonic), mediating the effect of the two dimensions of the sense of mattering and the sense of belonging on the two dimensions of mental well-being. Then, the two dimensions of mental well-being would have direct effects on time and study environment management, mediating the effects of the sense of mattering and belonging on self-regulated learning.

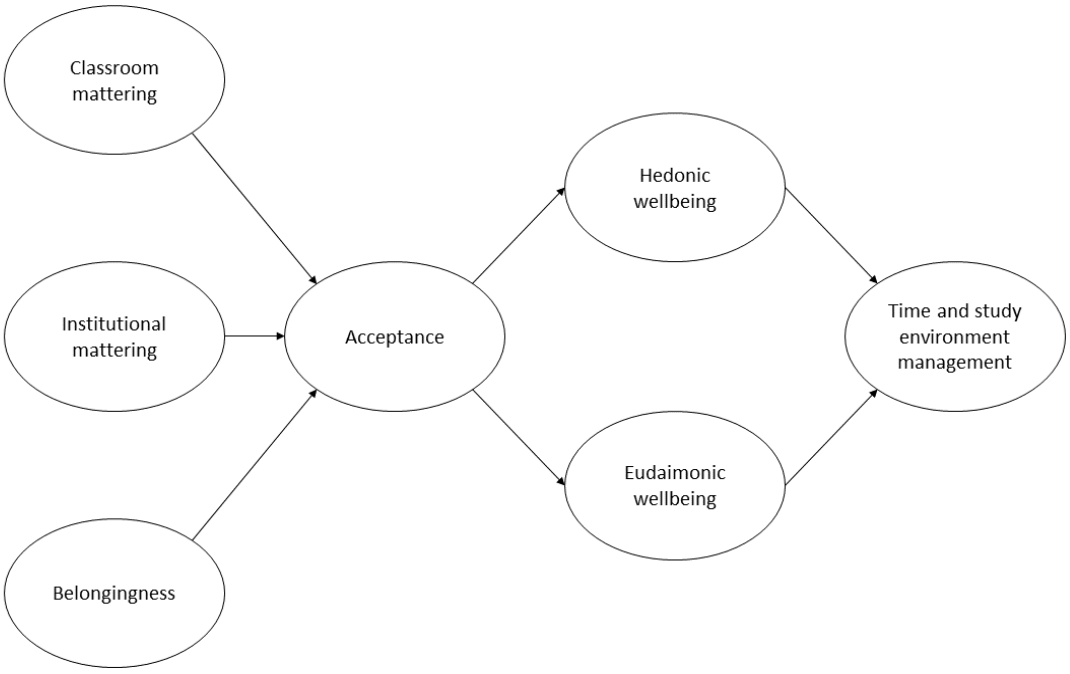

Figure 1: Proposed model

Results

The model proposed in Figure 1 was applied using Structural Equation Modeling, obtaining satisfactory fit indexes (RMSEA = 0.041; SRMR = 0.038; CFI = 0.998; TLI = 0.998), which indicates that the proposed relationships are capable of adequately reproducing the structure of variances and covariances observed between the items and the latent variables (further details about the distribution and normality or asymmetry of the items can be found at the following link: shorturl.at/bjlvV).

Figure 2 shows the regression coefficients (unidirectional lines) and covariances (bidirectional lines) between the latent variables. A first finding is that institutional mattering does not have a statistically significant effect on acceptance and, therefore, the other latent variables of the model. A second finding is that classroom mattering and belonging have effects on acceptance, which has quite strong effects on both dimensions of well-being (eudaimonic 0.54, hedonic 0.64). Finally, the eudaimonic dimension of well-being has a strong effect on time and study environment management (0.67), while the effect of hedonic well-being is not statistically significant.

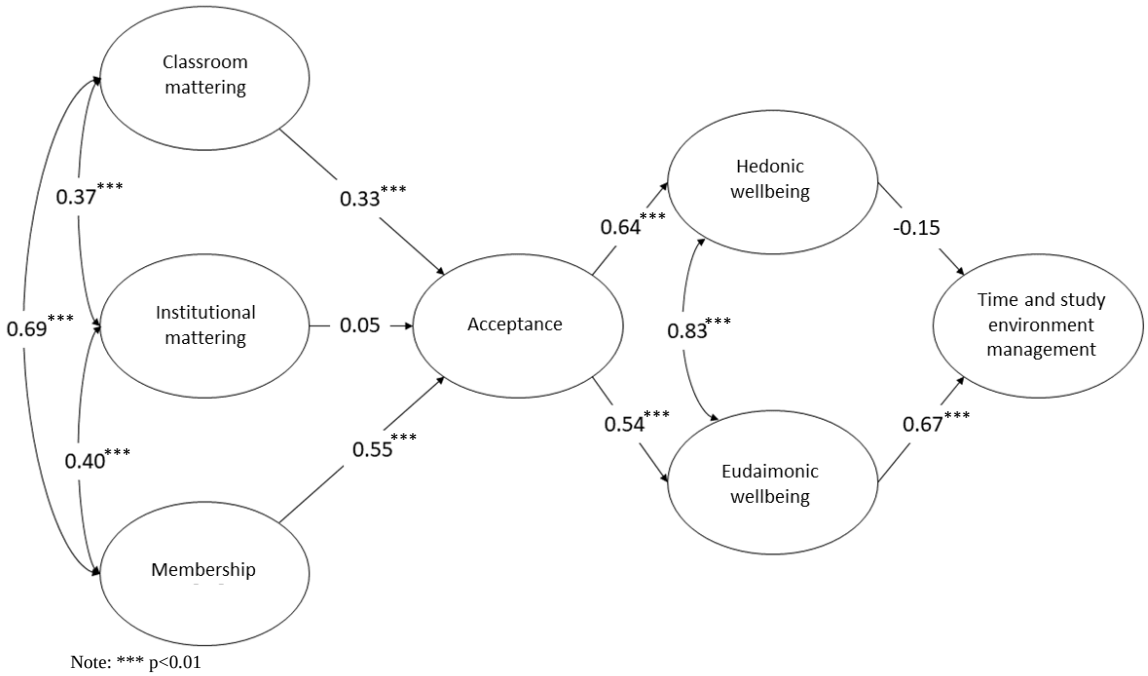

Figure 2: Path diagram, model output

Table 6 shows the most important indirect effects of the model. There it can be observed that acceptance would mediate an indirect effect from membership and from classroom mattering towards hedonic well-being and eudaimonic well-being. In turn, eudaimonic well-being (i.e. thinking clearly, facing problems, making decisions) mediates the indirect effect from Acceptance towards Time and study environment management. On the contrary, the effect of the hedonic dimension -which theoretically included closeness to other people, which was excluded in the model- is much smaller.

Finally, we could highlight the moderate indirect effect (0.20) from membership to time and study environment management, mediated by both acceptance and eudaimonic well-being.

Table 6: Summary of indirect effects

Predictor variable	Predicted variable	Indirect effect size
Membership	Hedonic well-being	0.35
Classroom mattering	Hedonic well-being	0.21
Membership	Eudaimonic well-being	0.30
Acceptance	Time and study environment management	0.36
Membership	Time and study environment management	0.20

Discussion

Based on the argument that the complex combination between a sense of mattering and a sense of belonging would have indirect effects on the self-regulated learning, mediated by the mental well-being of students, the theoretical model of Figure 1 was proposed as a hypothesis. This hypothesis proposes that classroom mattering, institutional mattering and membership would explain acceptance, which in turn would explain hedonic well-being and eudamonic well-being,

and in turn, these mental well-being dimensions would explain time and study environment management. Given that the model presents optimal indicators of fit to the data, the results provide empirical evidence in favor of the proposed hypothesis. However, the coefficients of the model also specify that there are effects that would not be relevant, such as the effect of institutional mattering on acceptance, and from hedonic well-being towards time and study environment management.

These results are in line with previous research in different aspects. On the one hand, the effect of the sense of mattering on mental well-being had already been observed in the works of Flett and other authors [20], [21], [25]–[28], [35]. Furthermore, other authors had demonstrated the positive effect of the sense of belonging on mental well-being [29]–[31]. Likewise, there are prior studies that have documented the relationship between mental well-being and self-regulated learning observed in this study [38]–[41], [45].

Regardless of the strong alignment of the obtained results with prior literature, the novelty of the findings of this study is their contribution to understand the specific mechanism through which the sense of mattering and belonging would affect the self-regulation of some behavioral aspects of learning, such as time and study environment management. This mechanism relies on the eudaimonic dimension of mental well-being. In this way, it is understood that the sense of mattering and sense of belonging contribute to the development of students' autonomy, which contributes to the way in which they manage their time and study environment.

Within engineering education, the main implication of this study is that it explains the negative consequences of a low sense of belonging in students' mental well-being and self-regulated learning skills [4], [46], [47]. This means that engineering schools need to continuously implement support interventions aimed at improving students' sense of belonging and sense of mattering [19], [21], which would have an important direct effect on the mental well-being, and a moderate and indirect effect on the way they manage their study time and space. In this context, this study also contributes with proposed scales to measure these constructs, so engineering schools can monitor their students' experiences, along with evaluating the effectiveness of actions implemented to improve their learning environments.

Still, this study is subject to some limitations. One of these limitations is that emotional self-regulation was not measured, which does not allow to compare the proposed model with the hypothesis of those works that argue that the relationship between well-being and self-regulated learning would be explained by emotional self-regulation [38]–[41]. A second limitation would be the incomplete measurement of self-regulated learning. As specified in the previous sections, it was decided to focus on behavioral aspects related to time and study environment management.

Consequently, the control of the effect that emotional self-regulation could have on the relationship between mental well-being and self-regulated learning remains open, so future work should incorporate other dimensions of self-regulation learning into the proposed model, analyzing how these are impacted by the two dimensions of mental well-being. Future work is also expected to estimate the indirect effect of the gaps in social integration of specific groups on their mental well-being and on the self-regulation of their learning.

Acknowledgements

Reserved for blind review.

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