

Self-Efficacy for Sustainable Gender Equality Practice in STEM Teacher Education in Spain and Greece

Cristina Miralles-Cardona

Ioanna Kitta

Dept. of Health Psychology, Faculty of Education, University of Alicante, Alicante, Spain

Abstract

In the context of the Education-2030 Framework for Action, an important goal for initial STEM teacher education is to provide professional development on equality and gender awareness. This study explored whether STEM prospective secondary teachers are prepared to implement a sustainable gender-sensitive practice upon graduation. To this end, we cross-culturally validated the TEGEP (Teacher Self-Efficacy for Gender Equality practice) scale and compared STEM student teachers' perceptions of self-efficacy by country and sex. Participants were 205 STEM (science, technology, engineering, and mathematics) secondary school student teachers (136 Greek and 69 Spanish) drawn from seven public universities (six Greek, one Spanish). Statistical analysis confirmed the structure and factor invariance of the TEGEP across country and between sexes showing evidence that gender equality self-efficacy level is only moderate and that perceived competence in gender knowledge was significantly higher in Greek than in Spanish STEM student teachers, while the latter felt more competent than the Greek in developing values and attitudes in regards to gender. The study provides a cross-validated instrument to measure gender equality self-efficacy in STEM teacher education and evaluate sustainable changes after planned interventions.

Keywords: Sustainable gender equality; self-efficacy; gender mainstreaming; STEM higher education; STEM student teachers' perceptions; scale validation, Spain, Greece

1. Introduction

For decades, gender equality (GE) has been a worldwide mission. Spain's efforts in promoting gender equality began in the 1980s with the institutionalization of GE policies at central and regional levels for the adoption of equity principles established in international and European Community regulations. As a signatory country of the United Nations' (UN) *Convention on the Elimination of All Forms of Discrimination against Women (CEDAW)* [1] and of the *2030 Agenda for Sustainable Development* [2], the Government of Spain formally established a number of legislation policies to guarantee quality inclusive education and same opportunities for all through the legitimization of gender equity policies and the institutionalization of equality bodies in the country. Some of the most influential regulations have been *PL 1/2004 on Comprehensive Measures Against Gender Violence* and *PL 3/2007 on Effective Equality of Men and Women* that regulate gender-based violence, equity in employment and workplace, care of dependent people, same-sex marriage, and sexual and reproductive rights [3,4]. Specifically, Article 4 (Point 1) of PL 1/2004, 'Principles and Values of the Educational System,' refers to social justice, equal opportunities, and gender equity as principles of the Spanish education system and Article 6 (Point 2) entrusts higher education institutions with the task of training for gender equality (p. 42169) urging for sexist and discriminatory stereotypes to be eliminated from all educational materials. However, significant institutional changes did not occur until the publication of PL 3/2007, which introduced methods and strategies for the effective incorporation of a gender perspective in all policies through the adoption of the gender mainstreaming (GM) intersectional approach, the creation of equality plans, and the establishment of a budget for measuring GM implementation and impact assessment [5]. The integration of the principle of equality in education policy, PL 3/2007 compels educational administrations to: (a) Pay special attention in the curricula at all educational levels to the principle of gender equality; (b) eliminate and refuse sexist behavior and stereotyped content that involve discrimination ... ; (c) mainstream gender into education programs for initial and permanent teacher training; and (d) promote a balanced presence of women and men in control and government bodies of school and higher education institutions (Point 2, p. 16). Concisely, PL 3/2007 in Art. 6, Point 2, forces universities to train future professionals to become competent in gender issues by mainstreaming gender into course content and study programs.

Similar to Spain, since the 1980s, Greece has been accepting the European Community and international recommendations on gender to guarantee personal, social and professional women rights. The country ratified the CEDAW (1979) through Law 1342/1983

and the Optional Protocol to the Convention (OP-CEDAW) relating to all forms of discrimination against women on December 10, 1999. In addition, the Greek Government enacted its own laws for the protection of women's labor, family and education rights through Law 1329/83 (BOE, 18/02/1983), which materialized the constitutional imperative of the principle of GE, and Law 4443/2016 to guarantee equal treatment against all types of discrimination. To help achieve these goals, policies of GE were boosted by the Community Support Framework funds leading during the nineties to the creation of two institutions (the General Secretariat for Equality and the Centre of Research for Gender Equality) that contributed to the implementation of GE policies but with a limited understanding of the appropriate gender mainstreaming methods and tools and under the pressure of feminist organizations. Although the first formal efforts to implement GM in Greece were in the 2000s when the General Secretariat for Gender Equality got actively involved in the planning process of the third and the fourth European Community Support Frameworks (2000-2006 and 2007-2013, respectively) [6], the most recent initiatives to improve GM in Greece can be found in the National Action Plan on Gender Equality 2016-2020, introduced in 2017 in the wake of the last recommendation of the Committee on the Elimination of Discrimination against Women in 2013, as well as in the Greek guidelines for the implementation of the 2030 Agenda for Sustainable Development, specifically Goal 4 (Ensure inclusive and equitable education for all) and Goal 5 (Achieve gender equality) [7].

Until now, all these initiatives that work to embed quality, equity and sustainability into the education systems have had little impact towards altering the curriculum, teaching approaches and teacher competencies to guarantee quality inclusive and equitable education for all. That has led to the acknowledgement that teacher education programs are failing to prepare future professionals to be inclusive as established in the global indicators: *Incheon Declaration for Education 2030* [8] and the *Global Education Monitoring Report 2020* [9] to which Target 4.c 'Substantially increase the supply of qualified teachers' requires putting into practice strategies to analyze and improve the quality of teacher education. In this regard, higher education institutions play a key role in formulating and mainstreaming GE policies into teaching, research and innovation through the generation of educational processes that favor the acquisition of knowledge, skills, and attitudes/values towards awareness of gender issues. Therefore, higher education institutions have a major responsibility in ensuring that all new graduates are well prepared for developing a sustainable gender-sensitive future professional practice.

Quality teacher education is essential to promote sustainability and achieve the desired changes [10]. Teachers' role is vital for raising gender awareness and facilitating the development of gender competencies necessary for a progressive and transformative STEM teacher education. With about 85 million teachers worldwide (9.4 million in early childhood, 30.3 million in primary, 18.1 in lower secondary, 14.0 in upper secondary, and 12.5 in tertiary education) [11], teachers are a significant target group taking into account that they are the single most important factor affecting how much students learn, how they learn, and what disposition and attitudes they have to face prejudices and inequalities in the STEM field. The issue is how to reach them and what to teach them as part of the Education for Sustainable Development (ESD) agenda. The UN Decade of Education for Sustainable Development implementation scheme [12] recognized that educators and trainers needed to be assisted with relevant knowledge and information to address ESD. However, Wals [13, pp. 50-51] noted that the extent to which ESD has been integrated into teacher education programs is unclear since: (1) limited knowledge of ESD at all levels is still a fundamental challenge to make ESD move beyond a focus on the environment; (2) ESD is still often carried out by a limited number of teacher training institutions at the national level and needs to be further mainstreamed into curriculum; and (3) more policy support is needed to guide ESD in teacher education and professional development.

Accordingly, across countries, higher education (HE) programs are failing to prepare future professionals, including STEM professionals, for a gender-sensitive practice [14,15,16]. This lack of preparation, as reported by Ferreira et al. [17], may be because the education of university students takes place in complex organizations that are autonomous and difficult to change, but also because of the vagueness of current gender equality policies, and androcentrism still prevailing in academic thinking [18, 19]. These arguments help explain why education for GE has not emerged as a priority in HE curricula and why gender competence development is practically absent in all HE degrees [19,20,21,22] the result being that graduates finish their career preparation without the necessary gender awareness, knowledge, and skills to develop and sustain a gender-sensitive professional activity.

In the European context, Mazur [23] compiled an overview of comparative research projects on gender equality and observed that GM implementation is clearly understudied. Most of this research has been conducted at national level [24,25] and the few studies that compare a set of countries [15,26,27] have come to agree that there is a great variability in gender mainstreaming conceptualization and practice. Moreover, there is a lack of instruments to measure implementation and to monitor progress. Research conducted at various Spanish

and Greek universities support these statements [20,28,29,30,31] reaffirming that gender mainstreaming is poorly developed and monitored.

Gender Equality in STEM Teacher Education

In regards to STEM education, the situation is even worse [32]. The STEM fields are considered especially important when promoting innovation, economic growth, and prosperity as stated in the 2030 Agenda. According to the UNICEF's [33] report, *Mapping Gender Equality in STEM from School to Work*, girls are less likely than boys to achieve high proficiency levels in STEM and have lower self-confidence in their STEM abilities than boys which are linked to gender gaps in their STEM engagement, interest and enjoyment. Consequently, fewer girls than boys aspire to careers in science, technology or engineering, even among top performers. These gender gaps in STEM engagement, interest, enjoyment, and future career aspirations are shaped by gender norms, biases and stereotypes that should be changed through education [34]. Women comprise about 40% of the STEM workforce across 68 countries; they are well represented in health but are acutely under-represented in engineering and technology jobs where they comprise just 28% of professionals. In addition, they are also under-represented in STEM-related jobs that do not require a professional degree making up approximately just a third of that workforce in the US.

Considering these disparities in STEM education and work, an important goal for teacher education today is to prepare STEM teacher candidates for confidence and awareness of gender imbalances and inequities. Gender equality can contribute to reducing sex segregation and gender stereotypes about women in STEM fields and favor the incorporation of more young students in these fields. If STEM-based education should teach STEM student teachers more than science and mathematics, the focus of STEM education requires developing a broader skill set, including not only creativity and skills for the 21st century but skills to live in a more just, fair and equitable world among which are skills for sustainable quality gender-sensitive practice. As Yogurtcu [35] stated, "we cannot achieve GE without first being educated, ... without representing it in the education system and recognizing gaps in equal education opportunities for all genders or underrepresented groups" (p. 1). Teacher education institutions must educate for gender equity and to this, first, we need to understand where we are and the work to be accomplished to reach this goal.

There are many advantages in studying GE issues in STEM education. For example, gender studies in STEM fields raise awareness on inequalities and discrepancies in power relations; promote understanding of personal and social values and intellectual merit irrespective of gender; are valuable in building gender equity institutional capacity and

enhancing their reputation; help to identify institutional problems related to gender equity; help institutions retain and advance women in STEM; help create and maintain successful programs that contribute to developing equal opportunities and preventing gender discrimination [36]. Hence, preparing STEM student teachers for GE should lead to an awareness of gender and an increase in knowledge, skills and attitudes to sustain a gender-sensitive professional practice. By increasing prospective STEM student teachers' confidence in their ability to teach inclusively and gender-sensitively future generations, we can help them gain confidence in their own potential for engagement in any STEM field, which will lower the risk of gender segregation and discrimination in such fields. Therefore, teaching gender in STEM teacher education and measuring student teachers' self-efficacy for GE practice is becoming more than a necessity.

Self-Efficacy for Sustainable Gender Equality Practice in STEM

Self-efficacy is the belief in one's ability to perform a specific task. It is defined as a judgment about one's ability to organize and execute the courses of action necessary to attain a specific goal [37]. Therefore, self-efficacy judgments are related to specific tasks in a given domain [38,39,40]. In the field of education, self-efficacy refers to teachers' beliefs in their ability to bring about desired student outcomes [41] being considered this ability a powerful predictor of higher student achievement and motivation [42], teachers' instructional practices, commitment, job satisfaction, and less teacher stress and burnout [43,44]. The positive effects of self-efficacy are commonly explained with Bandura's [32] self-efficacy theory, which states that self-efficacious people are more task-involved and persistent in the face of obstacles or new challenges. In STEM education, self-efficacy predicts academic performance beyond one's ability or previous achievement because confident individuals are motivated to succeed. For example, students with high science self-efficacy set more challenging goals and work harder to accomplish those goals than students with low science self-efficacy [45]. Among students who intend to major in STEM during college, those who leave STEM demonstrate lower self-efficacy than those who persist in STEM [46]. Once a sufficient level of self-efficacy is achieved, it serves as a source of domain specific motivation where people put forth more mental effort [47] and persistency [37]. In other words, self-efficacious student are more likely to display the positive affect, attitudes, and self-directed behaviors needed for active learning [48] that in the field of training for gender equality translates into the acquisition of knowledge, behaviors and dispositions to develop a teaching committed to gender equity.

Self-efficacy has been measured using various instruments and scales [49,50,51,52] in fields other than STEM education. It is very difficult to measure because it is a latent response variable and can only be measured indirectly often in the form of self-reported surveys [53]. A growing body of quantitative instruments are being designed to measure different aspects of self-efficacy (e.g. science self-efficacy [45] or computer use self-efficacy [54]) but not self-efficacy for GE. There seems to be unanimity in that it has to be specific to the construct and multi-dimensional. Therefore, since no specific instrument for measuring gender equality competence in STEM teacher education other than the TEGEP (Teacher Efficacy for Gender Equality Practice) scale [55] has been found, this study seeks to address this gap by adapting and validating this instrument to measure STEM student teachers self-efficacy based on their perception of their own GE competence. The study aimed:

- 1) To confirm the construct validity of the scale and explore its factor invariance across country (Greece and Spain) and sex. We hypothesized that the Greek version of the TEGEP would show a three-factor solution which is invariant with its original Spanish version.
- 2) To describe and compare cross-culturally by country and sex STEM student teachers' level of GE self-efficacy for sustainable GE practice upon graduation.

2. Materials and Method

This study included two parts. The first involved the cross-cultural validation of the TEGEP and the second a cross-sectional analysis of GE self-efficacy in STEM secondary student teachers by country and sex.

2.1. Study Design and Instrument

A confirmatory sequential design for cross-culturally validating the TEGEP and a survey approach were used as main designs of the current study. The Spanish version of the Self-Efficacy for Gender Equality Practice (TEGEP) scale [55] was used to collect data from the Spanish participants and a Greek adapted version (the TEGEP-G) from the Greek participants [56]. All the sections of the instrument were first translated into Greek by the author whose native language is Greek, but who is fluent in Spanish and English. A native Spanish speaker researcher in education, who is fluent in English, checked the content and quality of the translation. Finally, three experts on gender issues, proofread the translated Greek version of the instrument, and corrections were agreed by the authors to ensure maximum similarity with the original instrument.

The TEGEP, inspired by Rands' [57] principles for the development of gender equality (increase awareness and knowledge about gender, develop critical skills to think

about inequalities in complex ways, exercise gender-sensitive attitudes/values), UNESCO learning objectives for gender equality [58], and self-efficacy as a core aspect of Bandura's social-cognitive theory [38], consists of 22 items distributed in three subscales: Efficacy in Gender Knowledge and Awareness (9 items), Efficacy in Implementing a Gender Perspective (9 items), and Efficacy in Developing Gender Attitudes (4 items). Item statements begin with the expression 'I can...', 'I am confident...', or 'I am...' and are answered using six-response anchors ranging from 'strongly disagree' to 'strongly agree.' Higher scores on the TEGEP indicate a high perception of competence in one's ability to sustain a gender equality practice. On the contrary, low confidence in GE is indicative of low gender self-efficacy. In the current study, the TEGEP scale had a very high reliability (alpha coefficient for the whole scale was .94 Greek and .95 Spanish samples (.91, .93, and .89 vs .89, .93, and .85 for the subscales, Greek and Spanish, respectively). Previous studies using general education student teachers samples revealed that the scale is reliable and valid [55,59,60]. The scale allows us to obtain individual scores by item, factors, and a total score.

2.2. Participants and Procedure

The participants in this study were graduate STEM student teachers enrolled in seven public universities (six Greek, one Spanish) seeking a degree in secondary education. In these institutions gender equality and equal opportunities are considered a transversal competence to be developed, as can be cross-checked in their respective degrees' mission but, in practice, study plans and courses are free of gender equity issues [29,61].

Convenience sampling procedures were used to select participants. Greek students were invited to participate in an online survey (Google forms) via email or Facebook in the academic year 2018-2019. These respondents comprised Sample 1, which was composed of 136 last-year graduate science students ($n = 63$ math, $n = 32$ physics and $n = 41$ chemistry) from six Greek public universities. They were between 21-30 years old ($M = 22.03$, $SD = 1.48$), mostly males (70%) and Greek (97%). Sample 2 was drawn from the University of Alicante (UA), Spain. They were selected from the cohort of students enrolled in six of the 19 specialties (biology and geology, civil constructions, economy, computer science, sanitary processes, and technology) of a master's degree in secondary education at the College of Education and consisted of 69 graduate students in science ($n = 25$, 36%), technology ($n = 18$, 26%), engineering ($n = 12$, 18%), and math ($n = 14$, 20%). Data was collected in the 2018-2019 Spring semester. After obtaining permission from the institution and informed consent from participants, students who were present in class on survey administration day completed the questionnaire on paper during one of their required courses in their degree program. They

were between 22-52 years old ($M = 30.54$, $SD = 6.42$), homogeneously distributed by sex (54% males), Spanish (100%), and full-time students (73%). Only a minority reported having taken any elective course with a gender perspective or said they had previous knowledge on gender issues (6%). Overall, 75% of respondents had not received any previous training in gender (82.4% Greek and 68.1% Spanish); however, when asked about the importance they attach to gender education their rating was 7.13 ($SD = 2.54$) out of 10 (6.07 Greek and 8.18 Spanish).

The UA Research Ethics Committee deemed the study exempt from review.

2.3. Data Analysis

Preliminary analysis included the review of means, skewness and kurtosis of the items and reliability estimates that were obtained using Cronbach's alpha. To respond to the first aim of the study (explore the construct validity and factor invariance of the TEGEP), we investigated the factor structure of this instrument by running, first, a single-group confirmatory factor analysis (CFA) with the whole sample taking the three-factor model as its basic structure. Goodness-of-fit to the sample data was determined on the basis of: comparative fit index (CFI), Tucker Lewis index (TLI), root mean-square error of approximation (RMSEA), and standardized root mean square residuals (SRMR) [62]. Second, we used multiple group CFA to test the measurement invariance of the TEGEP across subsamples by country and sex. Recommendations for non-invariance were ΔCFI and $\Delta RMSEA > .015$ [63]. In responding to the second aim (to describe and compare cross-culturally participants' self-efficacy to sustain a GE practice) a series of two-way analysis of variance between groups (ANOVA 2x2) were executed taking country (Greece vs Spain) and sex (male vs female) as factors and GE self-efficacy as dependent variable. Statistical analyses were run using SPSS-26 and AMOS-23 versions.

3. Results

3.1. Construct Validity and Factor Invariance Across Country and Sex

Table 1 shows the means, standard deviations, skewness and kurtosis among the items of the TEGEP. All values of skewness and kurtosis were within an acceptable range (- 2, + 2), according to Muthén and Kaplan's recommendation [64]. The single-group CFA of the three-factor TEGEP structure reaffirmed a scale consisting of 22 items and a construct with three dimensions positively and statistically correlated ($p < .01$) that explained 66% of the total variance in both samples (Greek and Spanish). Model-fit indices (see Table 2) suggested that the proposed three-factor model is valid [$\chi^2(228) = 574.62$, $\chi^2/gl = 2.52$; RMSEA = 0.08, CFI = .90 y TLI = .90] and reliable (alpha's Cronbach of .94), thus confirming an adequate

construct validity of the TEGEP for the whole sample. The equivalence of this model tested across samples for examining the measurement invariance of the three-factor model by country and sex are presented in Table 2.

<Insert Table 1>

As can be seen, in regards to country, the goodness-of-fit statistics indicate that the configural, metric and scalar models across countries had acceptable fit statistics, according to RMSEA, and close to acceptable fit according to CFI and TLI. These model comparisons indicate that the TEGEP factors, loadings, and intercepts can be assumed to be equal since ΔCFI and $\Delta RMSEA$ are below the proposed cut point of .015. Thus, the TEGEP was found to have reasonable measurement invariance among countries. Then, the same models were examined for sexes and, as reflected in Table 2, the variations in CFI and RMSEA indices between models showed evidence of acceptable fit for RMSEA and close to acceptable fit indices for CFI. Thus, the TEGEP was found to have reasonable measurement invariance between sexes. Consequently, although the TEGEP three-factor model provides a modest fit to the data ($RMSEA < .08$, and ΔCFI and $\Delta RMSEA < .015$), in light of all the evidence (validity, reliability, and factor equivalence across samples), we concluded that the TEGEP has adequate psychometric properties to measure self-efficacy for gender-sensitive practice, both in the Greek and the Spanish STEM teacher education context and between sexes.

<Insert Table 2>

3.2. Differences in Perceptions of Self-Efficacy by Country and Sex

Since the TEGEP shows tenable invariance across countries and between sexes, mean comparisons result appropriate. The results of a 2x2 country by sex ANOVAs (Table 3) showed that although respondents from both countries reported only a moderate level of self-efficacy in knowledge and awareness of gender issues ($M = 4.46$ vs 4.09), in skills for teaching using a gender perspective ($M = 4.37$ vs 4.35) and in developing gender attitudes ($M = 4.54$ vs 4.81), the perceived efficacy in gender knowledge was significantly higher in Greek than in Spanish STEM student teachers [$F(1, 201) = 7.14, p = .008$], while the latter felt more competent than the Greek STEM students to develop values and attitudes in relation to gender [$F(1, 201) = 8.34, p = .004$], being these effects moderate [65].

<Insert Table 3>

In addition, a statistically significant interaction (country x sex) effect was found [$F(1, 201) = 25.64, p = .000$], suggesting that while male Greek STEM students rated significantly higher than their female peers their efficacy in developing gender values, on the contrary, female Spanish STEM students showed a higher disposition to develop gender-sensitive

attitudes and values than their male peers. In regards to Greece data, this finding seems a bit contradictory if one takes into account that women tend to suffer the consequences of gender stereotypes and discrimination more often than men (Institute for Women and Equal Opportunities, 2019) and, consequently, positive attitudes towards gender equality are usually more deeply rooted in women than in men, while males tend to underestimate gender privilege. In light of these results, it is crucial that teacher educators support STEM field students in increasing awareness and understanding of gender issues and challenge them.

4. Discussion and Conclusion

The purpose of this study was, first, to explore the construct validity of the TEGEP and examine its factor invariance across country (Greece and Spain) and sex and; second, to compare differences in STEM student teachers self-efficacy for developing a sustainable gender-sensitive practice. Preliminary results to cross-culturally explore the construct validity of the TEGEP scale suggest that this measure is a valid and reliable instrument for studying self-efficacy beliefs in ability for GE practice in STEM teacher education in Greece and Spain. In this regard, a first major finding is that the three-factor structure of the TEGEP has been confirmed and that configural, metric, and scalar invariance among Greek and Spanish STEM secondary student teachers and between male and female was tenable. This suggests that the TEGEP consistently measures the same construct among these groups and that mean scores represent the same latent level of self-efficacy among groups. Therefore, this provides evidence that studies using the TEGEP with these groups have reached conclusions that are not biased by different psychometric properties among groups and that mean comparisons in scores between these groups represent actual differences in GE self-efficacy and not merely differences in observed scores, so the researchers can continue to use the TEGEP in diverse samples. In addition, it may be the first time that scalar invariance is found across country and sex in secondary school STEM student teachers, since no studies have been carried out before with this population using the TEGEP. The finding of scalar invariance gives support to previous work by Miralles-Cardona et al. [55,60] using the TEGEP with general elementary and secondary education student teachers. A second major finding is that while the Spanish participants had significantly lower gender knowledge and awareness scores than Greek participants, self-efficacy for developing gender attitudes was significantly higher among Spanish than Greek respondents. However, a significant effect of the C x S interaction shows that while efficacy in gender attitude was significantly higher in male than in female Greek STEM secondary student teachers, the opposite occurs with Spanish students, in which case it

is female who had significantly higher level of confidence in developing gender attitudes than their male peers, being most of these effects medium to large, according to Cohen [65].

The present study contributed to the advancement of knowledge on teacher education for STEM secondary student teachers by providing a valid and reliable instrument to measure perceptions of competence for sustainable GE practice. The TEGEP scale is composed of three independent but related subscales that assess gender knowledge and awareness, attitudes and skills for developing a gender-sensitive professional practice. Given that the perception of self-efficacy is an affective-motivational variable on the basis of the good professional work, the validation of the TEGEP constitutes a contribution to the field by providing a tool that allows exploring GE self-efficacy in prospective STEM field teaching professionals. The instrument is also useful for identifying education needs and proposing curricular improvements to reduce the gap between preparation for GE and real efficacy for a sustainable and gender-sensitive practice. Furthermore, the study warns of moderately high levels of self reported GE efficacy, which considering the professional inexperience of the participants alerts to an unrealistic perception of ability for GE practice. These results are congruent with the findings of studies by Pendergast's et al. [66], which identified that regular education students in their formative period tend to report high levels of self-efficacy for future practice, despite lack of experience. Thus, providing future STEM graduates with learning opportunities and scenarios to critically reflect on the inequalities associated with gender in educational and work contexts is essential to identify discrepancies and imbalances that will undoubtedly contribute to reducing ignorance in relation to gender issues. Therefore, to improve GE competence in STEM teacher education we suggest efforts to increase gender knowledge, skills and attitudes by incorporating GE content into study programs as well as continuous reflection about gender in everyday social and education activity. In other words, to advance on the issue of gender equality in STEM teacher education, it is necessary to act in all social and educational contexts. One main concern in the field of STEM education is not only improving the performance of female students in STEM fields but male and female awareness of gender equity issues. There does not seem to be enough opportunities for reflection on gender equality in STEM teacher education, which makes it necessary to reverse this pattern and begin to infuse gender analysis into STEM curricula. Studying the obstacles that women often encounter throughout their educational and professional development will help to improve the educational and working climate and reduce segregation in certain STEM sectors.

Limitations

This study is not without limitations and its findings should be evaluated with caution. First, although the authors followed the same survey instrument, data collection was online in Greece and on paper in Spain. Second, all the variables were self-reported, so it is impossible to know the extent to which social desirability could influence participants' responses. Third, the fact that the sample was composed of STEM secondary student teachers of a limited number of institutions biased by size and gender (seven out of 10 Greek respondents were male) does not guarantee that the results can be generalized to other samples and institutions. Therefore, future studies with a broader and more diverse group of STEM student teachers from different institutions, degrees, regions and countries would be desirable. Finally, it is important to note that the study only provides information about the respondents' feelings of efficacy in general terms; that is, without taking into account modulating variables such as prior training in gender, motivation, or commitment to gender issues, so future studies should investigate how these variables can influence perceptions of efficacy for sustainable gender equality practice and empirically document the findings.

Conclusion

Even taking into account these limitations, the results of this study provide evidence of the construct validity and scalar invariance of the TEGEP scale being used in Greek and Spanish samples of STEM secondary student teachers. This implies that the meaning of the construct and of the items are the same in both cultures, so that both can be compared in their scores on the latent variables. That is, if a Greek and a Spanish STEM secondary student teacher obtained an average score of 5.00 in gender knowledge and gender awareness, it would indicate that both have the same level of knowledge in gender issues. This study also shows that while STEM Spanish student teachers had significantly lower gender knowledge and awareness than Greek participants, gender attitudes were significantly higher among Spanish than Greek respondents. Self-efficacy for developing gender attitudes was perceived significantly higher in male than females in the Greek context, just the opposite of what happened with the Spanish sample. Further study is needed to clarify the reason for these findings. Using a qualitative component to ascertain the factors affecting this response format would add understanding. Finally, this study also suggests that STEM teacher training in Greece and Spain does not meet the standards and demands that future STEM professionals need in gender equality. Gender mainstreaming in STEM teaching is scarce, not well articulated, optional and lacks well-prepared STEM secondary student teachers [28]. It is important to raise awareness and seek institutional compromise and responsibility in implementing a gender approach to university teaching in STEM teacher education. As Kitta

and Cardona-Moltó [7] stated, the necessity of complying with the demands for a quality, inclusive and gender-sensitive education brings a unique opportunity to infuse GE principles, strategies and issues of gender equity into STEM degrees, study plans and individual subjects.

Acknowledgements

This work was supported by grant (Ref. FJC2020-046278-I) co-financed by the State Research Agency of the Ministry of Science and Innovation, the European Union and the University of Alicante), and by the IUIEG (University Institute for Gender Studies Research, University of Alicante) (Ref. BOUA, 17/11/2020).

References

- [1] United Nations. *Convention on the Elimination of All Forms of Discrimination against Women* (CEDAW). United Nations: New York, NY, USA, 1979. Available online: <https://www.ohchr.org/en/instruments-mechanisms/instruments/convention-elimination-all-forms-discrimination-against-women> (accessed on 2 October 2022).
- [2] United Nations. *Transforming Our World: The 2030 Agenda for Sustainable Development*. United Nations: New York, NY, USA, 2015. Available online: <https://sustainabledevelopment.un.org/post2015/transformingourworld> (accessed on 2 October 2022).
- [3] Spanish Government. Organic Law 1/2004, of December 28, on Comprehensive Protection Measures against Gender Violence. Available online: <https://www.boe.es/buscar/act.php?id=BOE-A-2004-21760> (accessed on 15 August 2022).
- [4] Spanish Government. Organic Law 3/2007, of March 22, for the Effective Equality of Men and Women. Available online: <https://www.boe.es/buscar/act.php?id=BOE-A-2007-6115#:~:text=Esta%20Ley%20tiene%20por%20objeto,singularmente%2C%20en%20las%20esferas%20pol%C3%ADtica%2C> (accessed on 15 August 2022).
- [5] Cardona-Moltó, M. C.; Miralles-Cardona, C. Education for gender equality in teacher preparation: Gender mainstreaming policy and practice in Spanish higher education. In *Education as the Driving Force of Equality for the Marginalized*; Bolvin, J.; Pacheco-Guffrey, H., Eds.; IGI Global: Hershey, Pennsylvania, USA, 2022; pp. 65-89. <https://doi.org/10.4018/978-1-7998-8025-7>
- [6] European Institute for Gender Equality. *Gender Mainstreaming Approach: Greece*. (n.d.). Available online: <https://eige.europa.eu/gender-mainstreaming/countries/greece> (accessed on 30 October 2022).

- [7] Kitta, K.; Cardona-Moltó, M.C. Students' perceptions of gender mainstreaming implementation in university teaching in Greece. *J of Gend. Stud.* **2022a**, *31*, 457-477. <https://doi.org/10.1080/09589236.2021.2023006>
- [8] UNESCO. *Incheon Declaration: Education 2030: Towards Inclusive and Equitable Quality Education and Lifelong Learning for All*; UNESCO: Paris, France, 2015. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000233137> (accessed on 3 November 2022).
- [9] UNESCO. *Global Education Monitoring Report 2020: Inclusion and Education: All means All*; UNESCO: Paris, France, 2020. Available online: <https://en.unesco.org/gem-report/report/2020/inclusion> (accessed on 3 November 2022).
- [10] Gough, A. Teacher education for sustainable development: Past, present, and future. In *Teaching Education for Sustainable Development at University Level*; Leal Filho, W.; Pace, P., Eds.; Springer, Dordrecht, Germany, 2016; pp. 109-122.
- [11] The World Bank. *Teachers*. Available online: <https://www.worldbank.org/en/topic/teachers> (accessed on 3 November 2022).
- [12] UNESCO. *UN Decade of Education for Sustainable Development, 2005-2014: The DESD at a Glance*. UNESCO: Paris, France, 2005. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000141629> (accessed on 3 November 2022).
- [13] Wals, A. *Review of Contexts and Structures for Education for Sustainable Development 2009: Key Findings and Ways Forward*. UNESCO, Paris, France, 2009. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000187757> (accessed on 7 May 2022).
- [14] Han, S.W. National education systems and gender gaps in STEM occupational expectations. *Int. J. Educ. Develop.* **2016**, *49*, 175-187. <https://doi.org/10.1016/j.ijedudev.2016.03.004>
- [15] Silander, C.; Grange, I.; Pietilä, M.; Reisel, L. *Promoting gender equality in STEM-oriented universities: Institutional policy measures in Sweden, Finland and Norway*. In *Gender Inequalities in Tech-Driven Research and Innovation: Living the Contradiction*; Griffin, G., Ed.; Bristol University Press: Bristol, United Kingdom, 2022.
- [16] Zippel, K.; Ferree, M.M.; Zimmermann, K. Gender equality in German universities: Vernacularising the battle for the best brains. *Gender & Educ.* **2016**, *28*, 867-885. <https://doi.org/10.1080/09540253.2015.1123229>

- [17] Ferreira, J.A.; Ryan, L.; Davis, J. Developing knowledge and leadership in preservice teacher education systems. *Austr. J. Envir. Educ.* **2015**, *31*, 194-207. <https://doi.org/10.1017/ae.2015.24>
- [18] Lombardo, E.; Mergaert, L. Gender mainstreaming and resistance to gender training: A framework for studying implementation. *Nordic J. Femin. and Gend. Res.* **2013**, *21*, 296-311. <https://doi.org/10.1080/08038740.2013.851115>
- [19] Weiner, G. A critical review of gender and teacher education in Europe. *Pedag. Cult. & Soc.* **2000**, *8*, 233-247. <https://doi.org/10.1080/14681360000200091>
- [20] Valdivieso, S.; Ayuste, A.; Rodríguez-Menéndez, M.C.; Vila-Merino, E. Educación y género en la formación docente en un enfoque de equidad y democracia [Education and gender in teacher training in a focus on equity and democracy]. In *Democracia y Educación en la Formación Docente [Democracy and Education in Teacher Preparation]*; Carrillo-Flores, I., Coord.; University of Vic-Universidad Central de Cataluña: Barcelona, Spain, 2016; pp. 117-140.
- [21] Verdonk, P.; Benschop, Y.; de Haes, H.; Mans, L.; Lagro-Janssen, T. Should you turn this into a complete gender matter? Gender mainstreaming in medical education. *Gend. & Educ.* **2009**, *21*, 703-719. <https://doi.org/10.1080/09540250902785905>
- [22] Verge, T.; Ferrer-Fons, M.; González, M.J. Resistance to mainstreaming gender into the higher education curriculum. *Europ. J. Women's Stud.* **2018**, *25*, 86-101. <https://doi.org/10.1177/1350506816688237>
- [23] Mazur, A.G. Comparative gender and policy projects in Europe: Current trends in theory, method and research. *Comp. Europ. Polit.* **2009**, *7*, 12-36.
- [24] Beveridge, F.; Nott, S.; Stephen, K. Mainstreaming and the engendering of policy: A means to an end? *J. of Europ. Publ. Pol.* **2000**, *7*, 385-405.
- [25] Roggeband, C.; Verloo, M. Evaluating gender impact assessment in the Netherlands (1994-2004): A political process approach. *Polic. & Polit.* **2006**, *34*, 615-632.
- [26] Eveline, J.; Bacchi, C. What are we mainstreaming when we mainstream gender? *Int. Femin. J. Polit.* **2005**, *7*, 496-512.
- [27] Verloo, M.; Maloutas, M. Editorial: Differences in the framing of gender inequality as a policy problem across Europe. *Επιθεώρηση Κοινωνικών Ερευνών [The Greek Review of Social Research]*, **2005**, *117*, 3-10.
- [28] Alsina, M.; Más de les Valls, E.; Martínez, C.; Pino, D.; Peña, M.; Barahona-Fuentes, C. *STEM Students Perception of Gender Mainstreaming in Teaching: The*

- Development of a Measuring Tool*. Proceedings of ICERI Conference, Seville, Spain, 11-13 November 2019.
- [29] Kitta, I.; Cardona-Moltó, M.C. *Gender Mainstreaming in Teacher Education in Greece*. Paper presented at the Nineteenth International Conference on Diversity in Organizations, Communities & Nations, Patras, Greece, 5-7 June 2019.
- [30] Larrondo, A.; Rivero, D. A case study on the incorporation of gender-awareness into the university journalism curriculum in Spain. *Gend. & Educ.* **2019**, *31*, 1-14. <https://doi.org/10.1080/09540253.2016.1270420>
- [31] Maidou, A.; Plakitsi, K.; Polatoglou, H.M. Knowledge, perceptions and attitudes on education for sustainable development of pre-service early childhood teachers in Greece. *World Educ. J.* **2019**, *9*, 1-15. <https://doi.org/10.5430/wje.v9n5p1>
- [32] Fatourou, P.; Papageorgiou, Y.; Petousi, V. Women are needed in STEM: European policies and incentives. *Communications of the ACM*, **2019**, *62*, 52-57. <https://doi.org/10.1145/3312565>
- [33] UNICEF. *Mapping Gender Equality in STEM from School to Work*. UNICEF: New York, NY, USA, 2020. Available online: <https://www.unicef.org/globalinsight/media/1361/file> (accessed on 31 October 2022).
- [34] Bataineh, O.; Qablan, A.; Belbase, S.; Takriti, R.; Tairab, H. Gender disparity in science, technology, engineering, and mathematics (STEM): Programs at Jordanian universities. *Sust.* **2022**, *14*, 14069. <https://doi.org/10.3390/su142114069>
- [35] Yogurtcu, T. *The Role of STEM Education in Achieving Gender Equality*. Available online: <https://www.forbes.com/sites/forbestechcouncil/2022/05/20/the-role-of-stem-education-in-achieving-gender-equality/?sh=7ec3b8dc1491> (accessed on 31 October 2022).
- [36] Colatrella, C. *Why STEM Students Need Gender Studies*. Available online: <https://www.aaup.org/article/why-stem-students-need-gender-studies#.Y1QC2uzMI1I> (accessed on 30 September 2022).
- [37] Bandura, A. Self-efficacy: Toward a unifying theory of behavioral change. *Psych. Rev.* **1977**, *84*, 191-215. <https://doi.org/10.1037/0033-295X.84.2.191>.
- [38] Bandura, A. *Self-Efficacy: The Exercise of Control*. W. H. Freeman and Company: New York, NY, USA, 1997.
- [39] Pajares, F. Gender differences in mathematics self-efficacy beliefs. In *Gender Differences in Mathematics: An Integrative Psychological Approach*; Gallagher,

- A.M.; Kaufman, J.C., Eds.; Cambridge University Press, Cambridge, United Kingdom, 2005; pp. 294-315.
- [40] Zimmerman, B.J. Self-efficacy: An essential motive to learn. *Contemp. Educ. Psych.* **2000**, *25*, 82-91. <https://doi.org/10.1006/ceps.1999.1016>
- [41] Guskey, T.R.; Passaro, P.D. Teacher efficacy: A study of construct dimensions. *Amer. Educ. Res. J.* **1994**, *31*, 627-643. <https://doi.org/10.2307/1163230>
- [42] Caprara, G.V.; Barbaranelli, C.; Steca, P.; Malone, P.S. Teachers' self-efficacy beliefs as determinants of job satisfaction and students' academic achievement: A study at the school level. *J. School Psychol.* **2006**, *44*, 473-490. <https://doi.org/10.1016/j.jsp.2006.09.001>
- [43] Wang, H.; Hall, N.C.; Rahimi, S. Self-efficacy and causal attributions in teachers: Effects on burnout, job satisfaction, illness, and quitting intentions. *Teach. & Teacher Educ.* **2015**, *47*, 120-139. <https://doi.org/10.1016/j.tate.2014.12.005>
- [44] Zee, M.; Koomen, H.M. Teacher self-efficacy and its effects on classroom processes, student achievement adjustment, and teacher well-being: A synthesis of 40 years of research. *Rev. Educ. Res.* **2016**, *86*, 981-1015. <https://doi.org/10.3102/0034654315626801>
- [45] Hu, X.; Jiang, Y.; Bi, H. Measuring science self-efficacy with a focus on the perceived competence dimension: Using mixed methods to develop an instrument and explore changes through cross-sectional and longitudinal analyses in high school. *Int. J. STEM Educ.* **2022**, *9*, 47. <https://doi.org/10.1186/s40594-022-00363-x>
- [46] Shaw, E.; Barbutti, S. Patterns of persistence in intended college major with a focus on STEM majors. *NACADA J.* **2010**, *30*, 19-34.
- [47] Rittmayer, M.A.; Beier, M.E. Self-efficacy in STEM. In *Applying Research to Practice (ARP) Resources*; Bogue, B.; Cady, E., Eds. Available online: <http://www.engr.psu.edu/AWE/ARPresources.aspx> (accessed on 1 November 2022).
- [48] Pajares, F.; Schunk, D.H. Self-beliefs and school success: Self-efficacy, self-concept, and school achievement. In *International Perspectives on Individuals Differences: Self Perception*; Riding, R.; Rayner, S., Eds. Ablex Publishing: New York, NY, USA, 2001; pp. 239-266.
- [49] Gibson, S.; Dembo, M. Teacher efficacy: A construct validation. *J. Educ. Psych.* **1984**, *76*, 569-582. <https://doi.org/10.1037/0022-0663.76.4.569>
- [50] Sharma, U.; Loreman, T.; Forlin, C. Measuring teacher efficacy to implement inclusive practices. *J. Res. Spec. Educ. Needs*, **2012**, *12*, 12-21. <https://doi.org/10->

- 1111/j.1471-3802.2011.01200.x
- [51] Tschannen-Moran, M.; Woolfolk-Hoy, A.W. Teacher efficacy: Capturing an elusive construct. *Teach. & Teacher Educ.* **2001**, *17*, 783-805. [https://doi.org/10.1016/S0742-051X\(01\)00036-1](https://doi.org/10.1016/S0742-051X(01)00036-1)
- [52] Tsigilis, N.; Koustelios, A.; Grammatikopoulos, V. Psychometric properties of the Teachers' Sense of Efficacy Scale within the Greek educational context. *J. Psychoeduc. Assess.* **2010**, *28*, 153-162. <https://doi.org/10.1177/0734282909342532>
- [53] Judge, T.A. Core self-evaluations and work success. *Current Direc. Psychol. Sci.* **2009**, *18*, 58-62. <https://doi.org/10.1111/j.1467-8721.2009.01606.x>
- [54] Cassidy, S.; Eachus, P. Developing the computer user self-efficacy (CUSE) scale: Investigating the relationship between computer self-efficacy, gender and experience with computers. *J. Educ. Comput. Res.* **2002**, *26*, 133-153. <https://doi.org/10.2190/JGJR-0KVL-HRF7-GCNV>
- [55] Miralles-Cardona, C.; Chiner, E.; Cardona-Moltó, M.C. Educating prospective teachers for a sustainable gender equality practice: Survey design and validation of a self-efficacy scale. *Int. J. Sust. Higher Educ.* **2022**, *23*, 379-403. <https://doi.org/10.1108/IJSHE-06-2020-0204>
- [56] Kitta, I. *La Formación Inicial Docente en Igualdad de Género en Grecia: Percepciones y Competencias del Alumnado para una Práctica Profesional Sostenible Sensible al Género* [Initial Teacher Training in Gender Equality in Greece: Students' Perceptions and Competencies for a Sustainable Gender-Sensitive Professional Practice]. Doctoral dissertation, University of Alicante, Alicante, Spain, 6 July 2022.
- [57] Rands, K.E. Considering transgender people in education: A gender-complex approach. *J. Teach. Educ.* **2009**, *60*, 419-431. <https://doi.org/10.1177/0022487109341475>
- [58] UNESCO. *Education for Sustainable Development Goals: Learning Objectives*. UNESCO: Paris, France, 2017. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000247444> (accessed on 1 November 2022).
- [59] Kitta, K.; Cardona-Moltó, M.C. Competencias para la práctica de la igualdad de género en estudiantes universitarios griegos. *J. Int. Women's Stud.* **2022b**, *23*, 78-101. <https://vc.bridgew.edu/jiws/vol23/iss5/6>
- [60] Miralles-Cardona, C.; Cardona-Moltó, M.C.; Chiner, E. Assessing student teachers' perceptions of self-efficacy for a sustainable gender equality practice: A case study in

- Spain. In *Gender Equality: Past, Present and Future Perspectives*; Morel, H., Ed.; NOVA Science Publishers: Hauppauge, New York, NY, USA, 2021; pp. 179-202.
- [61] Miralles-Cardona, C. (2020). *Student Teachers' Perceptions, Competencies, and Attitudes Towards Gender Equality: An Exploratory Study*. Doctoral dissertation, University of Alicante, Alicante, Spain, 23 November 2022.
- [62] Kühne, R.J. Testing measurement invariance in media psychological research. *J. Media Psych.* **2013**, *25*, 153-159. <https://doi.org/10.1027/1864-1105/a000096>
- [63] Chen, F.F. Sensitivity of goodness of fit indexes to lack of measurement invariance. *Struc. Equat. Model.: A Multidisc. J.* **2007**, *14*, 464-504. <https://doi.org/10.1080/10705510701301834>
- [64] Muthén, B.; Kaplan, D. A comparison of some methodologies for the factor analysis of non-normal Likert variables. *Brit. J. Math. & Statist. Psych.* **1985**, *38*, 171-189. <https://doi.org/10.1111/j.2044-8317.1985.tb00832.x>
- [65] Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*. Lawrence Erlbaum Associates: Hillsdale, NJ, USA; 1988.
- [66] Pendergast, D.; Garvis, S.; Keogh, J. Preservice student teacher self-efficacy beliefs: An insight into the making of teachers. *Austr. J. Teach. Educ.* **2011**, *36*, 46-57.