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Moderating Effects of Gender on the Relationship between Senior School Physics Students' STEM Self-efficacy and Science Identity

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Abstract

The developmental growth of any society depends greatly on the progression and innovations made by students' in science, technology, engineering and mathematics. The current study determines the moderating effect of gender on the relationship between senior school physics students' STEM self-efficacies and science identity. The study was a co-relational study that employed the use of adopted questionnaires as found in the previous literatures to elicit information on students' STEM self-efficacies like science self-efficacy, engineering/technology self-efficacy, mathematics self-efficacy and students' science identity. The study adopted the usage of structural equation model and collected data were analyzed by SmartPLS software. The findings of the study revealed that physics students' science self-efficacy (β=0.174, p<.05), mathematics self-efficacy (β= -0.296, p<.05) and engineering/technology self-efficacy (β= -0.600, p<.05), and, has negative, positive, weak, substantial and significant relationship with physics students' science identity. The study further revealed that gender as a moderator variable significantly moderated the indirect relationship between physics students' science, technology, engineering and mathematics self-efficacies and their science identity. The study recommended that the physics students should be encouraged to see themselves as science person as this would influence their interest and decision to pursue a future career in science, technology, engineering and mathematics fields.

Keywords: STEM Self-efficacy, Science Identity, Gender, Relationship

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Introduction

The learners' ability to identify his/her area of weakness and strength explains the concept of learner's self-efficacy. Beatson et al. (2020) views self-efficacy as confidence in one's ability to succeed in a given task. Self-efficacy as the beliefs and ability to effectively perform tasks needed to attain a valued goal and positive outcomes (Maddux & Kleiman, 2016). Lamb et al. (2014) opined that student substantial self efficacy in STEM education can influence their educational endeavors and aid their career selection. Students STEM self efficacy serves as significant predictor of interests, career aspiration, outcome expectations and persistence among undergraduate in STEM fields (Butz, et al., 2018 & Awaludin, et al., 2023). Quintana and Saatcioglu (2022) asserted that students identifying with science or mathematics in school increase the enrolling odd in a STEM major in college and such student is expected to have a STEM career. Studying students' self-efficacy is important due to its strong association with students' learning outcomes (Bartimote-Aufflick et al., 2016). Hsieh et al. (2007) posited that studying self-efficacy aids students to understand their reason for non or underachievement in an area or field of studying, and dropping out of college as its significantly related to their academic standing. Honieke and Broadbent (2016) opined that student academic self-efficacy moderately correlates with their academic performance. The importance of the studying student academic self-efficacy is not limited to science, technology, engineering and mathematics education alone but extended to medical and humanities education. Filho et al. (2022) asserted that students' self-efficacy in medical education is essential because of its link to student motivation and performance. Mamaril et al. (2016) posited that studying students' self-efficacy is important because it's positively and significantly related to undergraduate engineering students' performance. Science identity remain a complex process been influenced by emotions and recognition that are linked to power, racism, exclusion and inequality (Avraamidou, 2020). Teacher STEM self-efficacy is a significant component of job performance and retention with patterned differences across gender and community of practice (Ofem, et al., 2021; Kelley, et al., 2020; & Menon, et al., 2023). Flowers and Banda (2016) opined that STEM self-efficacy is a critical factor for students to create a science identity and have trust and believe in their ability to engage in the learning and doing of sciences successfully. Aghekyan (2019) carried out a search on development and validation of science identity survey scale. The study adopted the items and construct from previous literatures and exploratory data analysis was used to analyze the collected responses. The exploratory factor analysis (EFA) analysis revealed the seven items were correlated and serves as observed/manifest variables of science identity. Sze et al. (2022) searched on the development of STEM self-efficacy.

Gender is an important factor that can influence learners' decision on science, technology, engineering and mathematics. Cheryan et al. (2017) asserted that masculine cultures contributed to larger gender gap in computer science, engineering and physics than any other areas in science and technology. Cimpian et al. (2020) emphasized that gender gap of male to female is 4 – 1 ratio in science and technology disciplines like physics, engineering and computer science. Saltiel (2022) attributed the female low math self-efficacy to their likelihood of STEM enrollment dropout rates.

Wang and Degil (2017) attributed the under representations of female students in mathematics intensive STEM fields to cognitive ability, relative cognitive strengths, lifestyle values, field-specific, ability beliefs, occupational interests and gender-related stereotypes and biases. Robnett (2016) submitted that lower STEM self-concept was associated with gender bias in STEM fields. Sun and Bian (2022) attributed three factors that includes cognitive skills, psychological factors, and socio-cultural effects to gender difference in STEM.

Miles and Naumann (2021) carried out a study on mediating role science self-efficacy in the relationship between gender and science identity. A Survey was administered to 964 US first year university students. The study focused on science self-efficacy mediating heterosexual and non-heterosexual students' gender and science identity. The findings of the study revealed that science self-efficacy mediated the relationship between gender and science identity for heterosexual students but not for non-heterosexual students.

The present study assessed the relationship between senior secondary school physics students' science, engineering/technology, and mathematics self-efficacies and their science identity.

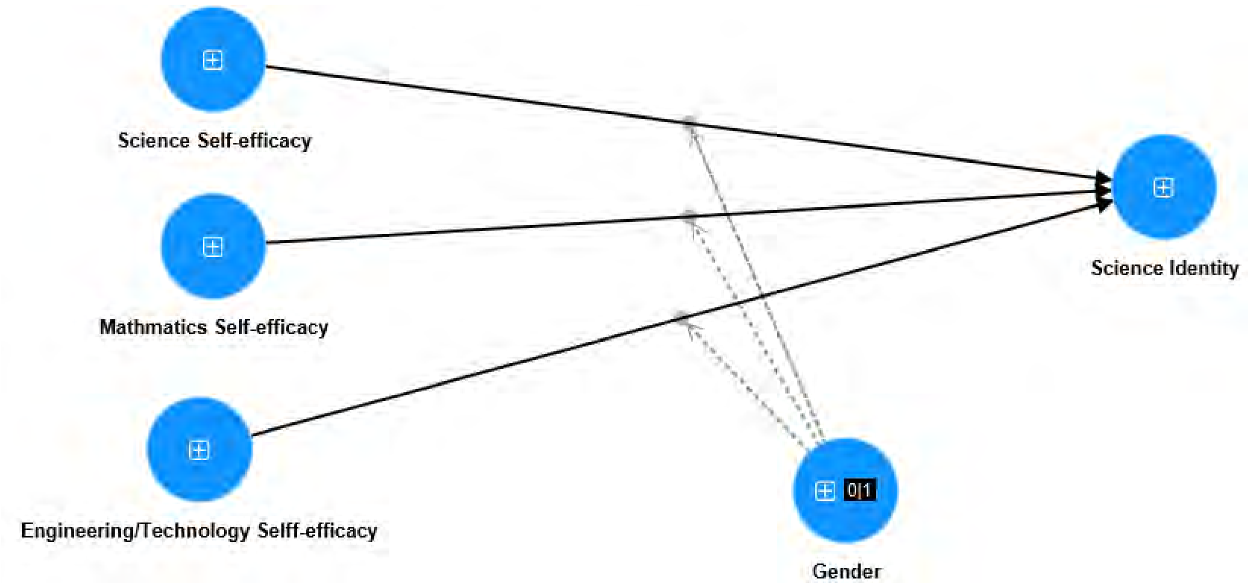

Fig. 1.0: The framework of the STEM Self-efficacies and Physics Students' Science identity.

Literature Review, Development of Research Questions and Formulation of Research Hypotheses

The following previous research outputs were reviewed as related to this present study.

Brown et al. (2016) carried out a study on STEM self-efficacy, interest and perception of middle school students. The study engaged 206 middle school students and Simpson-Troost attitude questionnaire was used to elicit information from the respondents. The result of the study revealed that there was moderate and significant correlation between STEM self-efficacy and students' intention to persist.

Aalderen-Smeets et al. (2019) carried out a search on STEM ability beliefs as a predictor of secondary school students' STEM self-efficacy beliefs and their STEM field career intention. The study engaged 483 senior secondary school students and multivariate statistical tool (structural equation model) was used to analyze the collected data. The results of the study revealed that positive relationship existed between incremental STEM ability beliefs and also predicted positive STEM self-efficacy beliefs and increased STEM intentions.

Williams and George-Jackson (2014) searched on the extent to which female and male students in STEM field identify as scientists. The study involved 1881 undergraduate result that were collected via online survey. An adopted science identity scale was used as instrument and result of the study shows that 36.5% male and 40.9% female sees themselves as being a scientist.

White et al. (2019) carried out a mixed method search on relationship between racial identity, science identity, science self efficacy and science achievement. The study involves 347 African American college students who attend black colleges and universities. The result of the study revealed that the college science achievement was significantly explained by science identity.

Alhadabi (2021) worked on science interest, utility, self-efficacy and high school students' science achievement. The data utilized in the study were collected from 14,815 high school students and obtained from a large scale database high school longitudinal study of 2009. The results of the study indicated that science self-efficacy has moderate and positive relationship with high school students' science identity.

Research Objectives

1. To determine the physics students' science, technology, engineering and mathematics self-efficacies;
2. To explore the relationship between physics students' science, engineering/technology, mathematics self-efficacies and their science identity;
3. To determine the moderating role of gender on the relationship between physics students' science, engineering/technology, mathematics self-efficacies and their science identity;
4. To determine the effect size of science, mathematics and engineering self-efficacies on students science identity;
5. To determine the variance of proportion of science identity explained by science, technology, engineering and mathematics self-efficacies.

Research Questions

RQ_1. What are the senior school physics students' science, mathematics and engineering/technology self-efficacies and science identity?

RQ_2. What is the effect size of science, mathematics and engineering/technology self-efficacies on physics students science identity?

RQ3. What variance proportion of the physics students' science identity does science, mathematics and engineering/technology self-efficacies explained?

Second Order Latent Variable	First/Higher Order Latent Variable	Construct's Meaning	Items' Code	Construct's Items	Validity Index	Source
STEM Self-efficacy	Science Self-efficacy	An ability to successful complete a task in science	SCI1	I can succeed with a career in science	>0.75	Items adopted from Sze et al., (2022)
			SCI2	I can perform in science tasks		
			SCI3	I can handle science with ease compared to other subjects		
			SCI4	I can do advanced work in science		
	Mathematics Self-efficacy	An ability to successful complete a task in mathematics	MAT1	I do succeed in math		
			MAT2	I can do advanced work in math	>0.75	

Second Order Latent Variable	First/Higher Order Latent Variable	Construct's Meaning	Items' Code	Construct's Items	Validity Index	Source
STEM Self-efficacy	Mathematics Self-efficacy	An ability to successful complete a task in mathematics	MAT3	I can handle math with ease compared to other subjects	>0.75	Items adopted from Sze et al., (2022)
			MAT4	I am good at math		
			MAT5	I can succeed with a career that uses math		
			MAT6	I can use math to invent useful things		
	Engineering Self-efficacy	An ability to successful complete a task in engineering	ENG1	I am good in creating new stuff	>0.75	Items adopted from Sze et al., (2022)
			ENG2	I am capable in tasks that involves manipulating machines		
			ENG3	I am good in building and fixing things		
			ENG4	I will have a successful career in engineering		

Second Order Latent Variable	First/Higher Order Latent Variable	Construct's Meaning	Items' Code	Construct's Items	Validity Index	Source
STEM Self-efficacy	Science Identity	Scientific qualities, beliefs and personality traits of being a scientist	SID1	Learning science in school will help me to succeed later in life	>0.75	Items adopted from Aghekyan (2019)
			SID2	I am confident I can master the skills taught in my science class		
			SID3	I consider science topics very interesting and engaging		
			SID4	When it comes to learning science, I think of myself as a science person		
			SID5	My peers and teachers think that I am knowledgeable in science		
			SID6	I am certain I can figure out how to do the most difficult science class work		
			SID7	My friends and family recognize me as a scientist		

Research Hypotheses

H_{01}. Science, mathematics and engineering self-efficacies positively and significantly correlated
with senior school physics students' science identity;
H_{02}. Gender positively and significantly moderated the relationship between science, mathematics and engineering self-efficacies and physics students' science identity;

Method and Measurement

This study was a co-relational study that uses the primary data gathered through face to face questionnaire administration to the senior secondary school physics students that are currently writing their external exit examination in 2023/2024 session. The choice of the respondents was based on the fact that the students are currently and will be applying for course to study at different tertiary institutions to science, technology/engineering and mathematics related careers. The EFA results of Sze et al. (2022) indicated that three factors that include mathematical self-efficacy, engineering/technology self-efficacy and science self-efficacy were outlined as the sub-constructs of the STEM self-efficacy which this study was adopted and rated on four Likert scale of strongly disagree, disagree, agree and strongly agree.. The data collected were analyzed based on variables' relationship. SmartPLS version 4.0.9.2 software was used to determine the relationship among variables.

Demographic Profile of the Respondents

The table 1 described the demographic profiles of the respondents. 300 respondents were engaged to participate in this study and were selected through non-probability sampling (Purposive Sampling). The valid returned questionnaires were 243 and were used to analyze the results. 114 representing 43.9% of the respondents' population were female while 129 representing 53.1% were male.

Table 1
Demographic Profile of the Respondents

Gender		N	%
	Female	114	46.9
	Male	129	53.1
	Total	**243**	**100**
Age	10-15	163	67.1
	16-20	66	27.2
	21-25	14	5.7
	25 & above	-	-
	Total	**243**	**100**

Results

Measurement Model

In this context, the values in matrix format represent the HTMT ratio which is used to evaluate the extent to which the each construct discriminates from other constructs in the formed model.

Heterotrait-monotrait (HTMT) of Correlations of the Constructs' **(**Discriminant Validity**)**

Table 2

Discriminant validity table for exogenous and endogenous constructs

Construct	Eng/Tech Self-efficacy	Gender	Mathematics Self-efficacy	Science Identity	Science Self-efficacy
Eng/Tech Self-efficacy					
Gender	0.221				
Mathematics Self-efficacy	0.311	0.305			
Science Identity	0.622	0.268	0.384		
Science Self-efficacy	0.327	0.241	0.475	0.773	

Convergent Validity

The tables 3 below contains the various reliability and validity indexes of the measured constructs in the model. Cronbach Alpha values measures the internal consistency and by extension the extent to which items of a scale or constructed are correlated. The Cronbach Alpha's value closer to 1 indicate stronger internal consistency. The composite reliability (rho_a and rho_c) are also alternative means of calculating the internal consistency of the constructs.

Average variance extracted (AVE) measures the amount of variance captured by the construct in relation to the amount of variance due to measurement error. A higher AVE value equal or above 0.5 indicated significant validity index.

Table 3

Construct validity table for the exogenous and endogenous variables

Construct	Cronbach Alpha	Composite Reliability Rho_a	Composite Reliability Rho_c	Average Variance Extracted (AVE)
Eng/Tech Self-efficacy	0.808	0.832	0.865	0.564
Mathematics Self-efficacy	0.792	0.468	0.758	0.368
Science Identity	0.753	0.795	0.824	0.419
Science Self-efficacy	0.727	0.794	0.835	0.568

RQ_1. What are the senior school students' science, mathematics and engineering self-efficacies?

Table 4

Mean and standard deviation results of the physics students' science self-efficacy, engineering/technology science self-efficacy, mathematics self-efficacy and students' science identity

	M	SD
Physics Students' Science Self-efficacy	3.448	0.760
Physics Students' Mathematics Self-efficacy	3.250	0.587
Physics Students' Engineering/Technology Self-efficacy Statement	2.908	0.823
Science Identity	3.167	0.859

The mean score of 3.448, 3.250, and 2.908 of a constructs measured in four likert scales indicated that the physics students have high self-efficacy in science, engineering/technology and mathematics. The mean score of 3.167 also revealed that physics students highly recognized themselves as science person.

Structural Model

Testing of the Research Hypotheses

H_{01}. Science, mathematics and engineering/technology self-efficacies positively and significantly correlated with senior school students' science identity;

The results from the table 8 below explained the relationship status between STEM self-efficacies and students' science identity. Science self-efficacy has weak, positive and significant relationship with students' science identity (β=0.174, $p<.05$). Mathematics self-efficacy has moderate, negative and significant relationship with students' science identity (β=-0.296, $p<.05$) and engineering/technology self-efficacy has substantial, negative and significant relationship with students' science identity (β=-0.600, $p<.05$).

Table 5

Direct coefficient table of science, engineering/technology, mathematics self-efficacies and physics students' science identity

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
Science self-efficacy -> Science identity	0.174	0.167	Positive/Low	3.067	0.002	Supported
Mathematics self-efficacy -> Science identity	-0.296	-0.307	Negative/Moderate	5.808	0.000	Supported
Engineering/Technology self-efficacy -> Science identity	-0.600	-0.608	Negative/Substantial	9.060	0.000	Supported

H_{02}. Gender positively and significantly moderated the relationship between science, mathematics and engineering/technology self-efficacies and students' science identity;

The results from the table 9 below explained the relationship status between STEM self-efficacies and students' science identity when moderated by gender. Science self-efficacy has substantial, positive and significant relationship with students' science identity when moderated by gender (β=0.603, $p<.05$). Mathematics self-efficacy has moderate, positive and significant relationship with students' science identity when moderated by gender (β=0.225, $p<.05$) and engineering/technology self-efficacy has moderate, positive and significant relationship with students' science identity when moderated by gender (β=0.265, $p<.05$).

Table 6

Indirect coefficient Table of science, engineering, mathematics self-efficacies and science identity

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
Gender× Science self-efficacy -> Science identity	0.603	0.604	Positive/Substantial	12.100	0.000	Supported
Gender× Mathematics self-efficacy -> Science identity	0.225	0.231	Positive/Moderate	4.248	0.000	Supported
Gender× Engineering/Technology self-efficacy -> Science identity	0.265	0.272	Positive /Moderate	4.058	0.000	Supported

RQ_3. What is the effect size of science, mathematics and engineering self-efficacies on physics students' science identity?

The table 10 above explained the effect size of the STEM self-efficacy sub-constructs. Science self-efficacy and gender has weak/low effect size on students' science identity (f^2=0.041, 0.014), while mathematics and engineering/technology self-efficacies has moderate effect size on students' science identity (f^2=0.260, 0.220).

Table 7

The effect size (f^2 values) of the science, mathematics, engineering/technology and gender on the physics students' science identity

Sub-constructs	f^2
Science Self-efficacy	0.041
Gender	0.014
Mathematics Self-efficacy	0.260
Engineering/Technology Self-efficacy	0.220

RQ4. What variance proportion of the science identity does STEM self-efficacy explained?

The R^2 value in table 11 below shows the variance of students' science identity been explained by the science, engineering/technology, mathematics and gender. The R^2 value of 0.663 indicated that 66.3% of the physics students' science identity is been explained by science, engineering/technology, mathematics and gender.

Table 8

The coefficient of determination/explanatory power (R^2 value) of the exogenous constructs on the students' science identity

	R-square	R-square adjusted
Science Identity	0.663	0.658

Discussion

The present search determines the moderating effect of gender physics students' STEM self-efficacy and its relationship with science identity. The result of the research questions 1 indicated that physics students had moderate self-efficacies in science, engineering/technology and mathematics. The result of the research question 1 revealed that the physics students has the scientific beliefs, qualities and values that can qualifies them as a science person. The direct relationship result between attitude to science, engineering/technology, and mathematics self-efficacies of physics students' and their science identity were relatively low, moderate, substantial negative, positive and significantly correlated. The indirect relationship result when moderated by gender indicated that the relationship between science, engineering/technology and mathematics self-efficacies of physics students and their science identity when moderated by gender were moderate, substantial, positive and significantly correlated. The indirect relationship findings was in line with the results of Alhadabi (2021) that concluded that gender significantly moderated the relationship between science, engineering/technology, mathematics self-efficacies and physics students' science identity. The effect size (f^2) results of the exogenous variables indicated the science, engineering/technology and mathematics self-efficacies have a significant effect size on science identity and the coefficient of determination or explanatory power (R^2) value implies that 66.3% of the students' science identity was explained by the science, engineering/technology and mathematics self-efficacies and science identity.

Conclusion

The findings of this work show the correlation strengths, direction and significance of the physics students' science identity and science, engineering/technology and mathematics self-efficacies. The study employed the usage of the modern statistical method known as structural equation model. The data collected were analyzed via SmartPLS software. The result of this study shows that science, engineering/technology and mathematics self-efficacies and play a significant role in the science identity of physics students. The findings of the students also concluded that students' gender play significant moderating role on the relationship of physics students' science identity and science, engineering/technology and mathematics self-efficacies. The result of this study implies that physics students still have high self-efficacies in science, engineering/technology and mathematics and this signifies that the reasonable of these students would pursue career in STEM. The study recommended that studies on students' self-efficacies should be carried out often as this would reveal the true reflection of students' belief, ability, and readiness to pursue career in science, technology, engineering and mathematics.

References

Aalderen-Smeets, S. I., Molen, J. H. W., & Xenidou-Dervou, I. (2019). Implicit STEM ability beliefs predicts secondary school students' STEM self-efficacy beliefs and their intentions to opt for a STEM field career. *Journal of Research in Science Teaching, 56*(4), 465-485. https://doi.org/10.1002/tea.21506

Aghekyan, R. (2019). Measuring high school students science identities, expectations of success in science, values of science and environmental attitudes: development and validation of the SIEVEA survey. *Science Education International, 30*(4), 342-353. https://doi.org/10.33828/sci.v30.i4.12

Alhadabi, A. (2021). Science interest, utility, self-efficacy, identity and science achievement among high school students: an application of SEM tree. *Front. Psychol. 12*:634120. https://doi.10.3389/fpsyg.2021.634120

Avraamidou, L. (2020). Science identity as a landscape of becoming:rethinking recognition and emotions through an intersectionality lens. *Cultural Studies of Science Education, 15,* 323-345. https://doi.org/10.1007/s1142-019-09954-7

Awaludin, A., Ruhiyat, Y., & Anriani, N. (2023). The effects of STEM learning model and self efficacy on students' learning outcome. *PPSDP International Journal of Education.* https://doi.org/10.59175/pijed.v2i2.109.

Bartimote-Aufflick, K., Bridgeman, A., Walker, R., Sharma, M., & Smith, L. (2016). The study, evaluation, and improvement of university student self-efficacy. *Studies in Higher Education, 41*, 1918-1942. https://doi.org/10.1080/03075079.2014.999319

Brown, P. L., Concannon, J. P., Marx, D., Donaldson, C. W., & Black, A. (2016). An examination of middle school students STEM self-efficacy, interests and perception. *Journal of STEM Education: Innovations and Research, 17*(3), 27-38.

Butz, A., Byars-Winston, A., Leverett, P., Branchaw, J., & Pfund, C. (2018). Promoting STEM trainee research self-efficacy: a mentor trainee intervention. *UI Journal*, 91.

Cheryan, S., Ziegler, S., Montoya, A., & Jiang, L. (2017). Why are some STEM fileds more gender balanced than others? *Psychological Bulletin, 143,* 1-35. https:/doi.org/10.1037/bul0000052

Cimpian, j., Kim, T., & McDermott, Z. (2020). Understanding persistent gender gap in STEM. *Science,* 368, 1317-1319. https://doi.org/10.1126/science.aba7377

Filho, J., Murgo, C., & Franco, A. (2022). Self-efficacy in medical education:a systematic review of literature. *Educacao em Revista*. https://doi.org/10.1590/0102-469835900t.

Flowers, A., & Banda, R. (2016). Cultivating science identity through sources of self-efficacy. *Journal of Multicultural Education, 10*, 415-417. https://doi.org/10.1108/JME-01-2016-0014

Honieke, T., & Broadbent, J. (2016). The influence of academic self-efficacy on academic performance: a systematic review. *Educational Research Review, 17*, 63-84. https://doi.org/10.1016/JEDUREV.2015.11.002

Hsieh, P., Sullivan, J., & Guerra, N. (2007). A closer look at college students: self-efficacy and goal orientation. *Journal of Advanced Academics, 18*, 454-476. https://doi.org/10.4219/jaa-2007-500.

Kelley, T., Knowles, J., Holland, J., & Han, J. (2020). Increasing high school teachers self-efficacy for integrated STEM instruction through a collaborative community of practice. *International Journal of STEM Education, 7*. https://doi.org/10.1186/s40594-020-00211-W

Lamb, R., Vallett, D., & Annetta, L. (2014). Development of a short-form measure of science and technology self-efficacy using Rasch analysis. *Journal of Science Education and Technology,* 23, 641-657. https://doi.org/10.1007/s10956-014-9491-Y

Maddux, J., & Kleiman, E. (2016). Self-efficacy: a foundational concept for positive clinical psychology. 89-101. https://doi.org/10.1002/9781118468197.CH7

Mamaril, N., Usher, E., Li, C., Economy, D., & Kennedy, M. (2016). Measuring undergraduate students' engineering self-efficacy: a validation study. *Journal of Engineering Education, 105.* https://doi.org/10.1002/jee.20121.

Memon, D., Shorman, D., Cox, D., & Thomas, A., (2023). Pre-service elementary teachers conceptions and self-efficacy for integrated STEM. *Education Sciences.* https://doi.org/10.3390/educsci13050529

Miles, J. A., & Naumann, S. E. (2021). Science self-efficacy in the relationship between gender & science identity. *International Journal of Science Education, 43*(17) 2769-2790. https://doi.org/10.1080/09500693.2021.1986647

Ofem, B., Polizzi, S., Rushton, G. Beeth, M., Couch, B., Doering, J., Konz, R., Mohr-Schroeder, M., Roehrig, G., & Sheppard, K. (2021). Looking at our STEM teacher workforce: how to model self-efficacy. *Economic Development Quarterly*, 35, 40-52. https://doi.org/10.1177/0891242420973758

Robnett, R. (2016). Gender bias in STEM fields. *Psychology of Women Quarterly*, 40, 65-79. https://doi.org/10.1177/0361684315596162

Saltiel, F. (2022). Multidimensional skills and gender differences in STEM majors. The *Economic Journal*. https://doi.org/10.1093/ej/ueac079

Sun, K., & Bian, X. (2022). A systematic review about gender difference in STEM performance for adolescents. *Advances in Social Science, Education and Humanities Research*. https://doi.org/10.2991/assehr.k.211220.083.

Sze, A. W. K., Hassan, N. C., Jaafar, W. M. W., Ahmad, N. A., & Arsad, N. M. (2022). Development of a STEM self-efficacy scale for Malaysian primary school children: a validity and reliability study. *Asia-Pacific Social Science Review*, 22(1), 47-59.

Quintana, R., & Saatcioglu, A. (2022). The long-lasting effects of schooling: estimating the effects of science and math identity in high school on college and career outcomes in STEM. *Socius,* 8. http://doi.org/10.1177/23780231221115405

Wang, M., & Degil, J. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): current knowledge, implications for practice, policy, and future directions.
Educational Psychology Review,29, 119-140. https://doi.org/10.1007/s10648-015-9355-x

White, A. M., DeCuir-Gunby, J. T., & Kim, S. (2019). A mixed methods exploration of the relationships between the racial identity, science identity, science self efficacy and science achievement of African American students at HBCUs. *Contemporary Educational Psychology,* 57, 54-71. https://doi.org/10.1016/j.cedpsych.2018.11.006

Williams, M. M., & George-Jackson, C. E. (2014). Using and doing science: gender, self-efficacy and science identity of undergraduate students in STEM. *Journal of Women and Minorities in Science and Engineering, 20*(2), 99-126.

.