MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2022, 18(4), em2250
ISSN:1305-8223 (online)
OPEN ACCESS Review Article https://doi.org/10.29333/ejmste/13086

# Exploring the role of motivation in STEM education: A systematic review

Almira R. Bayanova [1*], Natalia A. Orekhovskaya [2], Natalia L. Sokolova [3], Elena F. Shaleeva [3], Svetlana A. Knyazeva [4], Roza L. Budkevich [5]

[1] Kazan (Volga Region) Federal University, Kazan, RUSSIA
[2] Financial University Under the Government of the Russian Federation, Moscow, RUSSIA
[3] Peoples' Friendship University of Russia (RUDN University), Moscow, RUSSIA
[4] I.M. Sechenov First Moscow State Medical University (Sechenov University), Moscow, RUSSIA
[5] Almetyevsk State Oil Institute, Almetyevsk, Republic of Tatarstan, RUSSIA

Received 03 January 2023 ▪ Accepted 14 March 2023

**Abstract**
Motivation is an essential factor influencing learners' active participation in STEM subjects and their decision to study STEM fields. This study aimed to determine the current state of research on motivation and STEM and systematically review the current research in the literature. The study examined 78 articles published in journals indexed in the SCOPUS database. Two researchers collected and analyzed the data using the content analysis method. The results showed that the first research on motivation and STEM were published in 2008, and most research papers were published in 2021. The results also showed that most studies were conducted in the United States (47.8%), and the preferred participants were undergraduates (28.1%), high school students (26.7%), and middle school students (14%), respectively. In addition, the results revealed that researchers primarily used the quantitative method to collect data, and a substantial ratio of the studies (83%) investigated student-level factors. Based on the results obtained from this study, it can be concluded that there is a need to comprehensively present the main research results on motivation in STEM education. We suggest that future research should examine databases such as ERIC, ProQuest, and Web of Science and include other documents in the analysis, including book chapters, conference papers, dissertations, and theses.

**Keywords:** motivation, STEM education, review, science, mathematics, technology

## INTRODUCTION

STEM education aims to develop learners' knowledge and skills in science, technology, engineering, and mathematics, such as creativity, critical thinking, and problem-solving (Hasanah, 2020; Martynenko et al., 2023; Shchemeleva, 2020). With the advent of STEM education in 2009 in the United States (White House Office of the Press Secretary, 2009), researchers have developed formal and informal education programs for students at various levels, from kindergarten through undergraduate, to provide STEM skills that will prepare them for the future (e.g., Belayneh, 2021; Chittum et al., 2017; Morgan et al., 2022; Parks et al., 2021; Schnittka et al., 2012). In parallel with these educational advances, many nations have developed new curricula for STEM education and updated their existing curricula according to the skills that STEM education requires (Andreev et al., 2020; National Science & Technology Council, 2013; Ritz & Fan, 2015). In this way, nations also wanted to take action to educate their students and provide them with skills in the face of changing developments such as global warming, hazardous chemicals, new technologies, environmental protection, and ensuring prosperity in the face of changing world conditions (Hasanah, 2020; Ng, 2020; Ritz & Fan, 2015). In addition to developments, a decline in students preferring college-level STEM fields in many countries has made STEM instruction increasingly important (Akgunduz, 2016; Ng, 2020). For these reasons, governments have placed significant importance and urgency on developing STEM


✉ almira-djl@mail.ru **(*Correspondence)** ✉ naorehovskaya@fa.ru ✉ n.sokolova@rudn.ru ✉ shaleeva-ef@rudn.ru
✉ svknyazeva@mail.ru ✉ Budkevichrl@yandex.ru

**Contribution to the literature**

- STEM research and educational policy documents emphasize that learner motivation is important to promote learning outcomes such as active engagement, interest, and achievement in STEM education.
- Although previous studies on STEM education have been conducted to understand learner motivation and the relationships between motivation and other variables that influence their motivation in STEM education, only two previous studies have included an analysis of research studies on motivation and STEM.
- There is a research gap in the literature regarding a systematic review of studies that address motivation and STEM. This gap highlights the need for a comprehensive review study of the role of motivation in STEM education.

instruction and have supported education stakeholders to encourage and promote students in STEM subjects (Tawbush et al., 2020). For these reasons, it has become apparent that there is a need to encourage students to STEM fields and prepare them to work in STEM fields in a technology-driven world.

In increasing the importance given to STEM teaching, the results of international tests such as PISA and TIMSS, in particular, have shown that students' STEM skills are not good and are not increasing compared to previous test results (Roungos et al., 2020). In particular, numerous studies have shown that student interest and skills in mathematics and science test scores have declined significantly in OECD countries in recent years (Jeffries et al., 2020). The dramatic declines in student test scores have alarmed many countries worldwide and prompted them to take action to prevent this decline among students.

The actions that must be taken to prevent the decline of student interest and motivation in STEM fields aim to encourage them to pursue STEM careers. STEM research and educational policy documents emphasize the importance of motivation in STEM education. Researchers agree that learner motivation is important in fostering learning outcomes such as active engagement, interests, and achievement in STEM education (Fiorella et al., 2021; Salsa et al., 2022). Specifically, research has found that motivation is one of the affective factors influencing learners' interest, learning outcomes, and career choices in STEM fields (Saleh et al., 2019; Salsa et al., 2022). With this aspect of research findings, motivation has become very important in influencing learners' interests, encouragement of their work in STEM subjects, and career choice decisions in STEM fields. For all these reasons, further insights into the state of research on motivation and STEM education are needed. Since the emergence of STEM, researchers have focused on the role of motivation as an affective factor that influences learners' preferences and careers in studying in STEM fields. Despite the great importance placed on motivation in learners' choices and decisions to pursue careers in STEM fields, only two studies (Murphy et al., 2019; Saleh et al., 2019) have reviewed research on motivation and STEM.

Although previous studies on STEM education have been conducted to understand learners' motivation and the relationships between motivation and other variables that affect their motivation in STEM education, only two previous research included an analysis of research studies on motivation and STEM. In these studies, Saleh et al. (2019) aimed to review related articles on the role of interest and motivation in STEM education between 2011 and 2019. However, the number of articles they analyzed was limited (n=18). In another research, the review by Murphy et al. (2019) synthesized the literature on student motivation and academic emotions to provide relevant insights into student STEM's effect. Although they paid particular attention to outcomes related to gender and educational interventions that emphasize motivational models, they did not conduct a systematic review of research on motivation and STEM education. For this reason, it is necessary to review studies in the literature on motivation and STEM. In this regard, there is a research gap in the literature regarding a systematic review of studies that address motivation and STEM. This gap highlights the need for a comprehensive review study on the role of motivation in STEM education. In light of this research gap, the purpose of this study was to provide a systematic review of research studies on motivation and STEM, identify trends and gaps in the literature by comprehensively examining how motivation and STEM are used in education, and classify the research.

# METHOD

## Article Selection Process

The researchers used the SCOPUS database to select articles for this review study. For this purpose, the researchers searched using the keywords in **Table 1** and

**Table 1.** Inclusion and exclusion criteria

| Search items | Search limiters | NS |
|---|---|---|
| "Motivation" & "STEM"* | Peer-reviewed journals<br>Extra limiters<br>Language: English<br>Document type: Article<br>Subject area: Social sciences | 78 |

Note. Searches included in title & NS: Number of studies

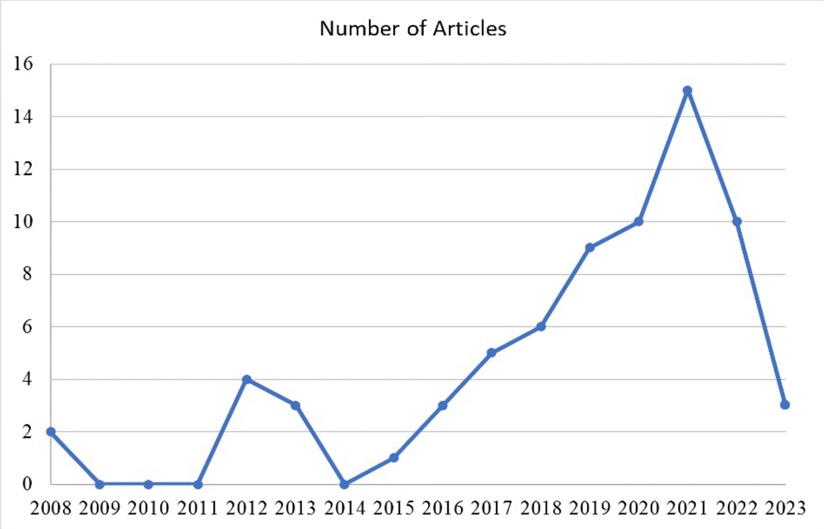


**Figure 1.** Distribution of research by publication year (Source: Authors' own elaboration)

narrowed the search results according to the criteria in **Table 1**. The researchers selected articles on motivation and STEM published in the SCOPUS database. On the website SCOPUS, the researchers used an advanced search option using the keywords "motivation" and "STEM." Then, the researchers used the restriction option to exclude unrelated articles from the database and found 78 related articles after applying exclusion criteria with the search criteria. The search results were limited to articles, the document type was specified as "article," and the language was defined as "English" in the search filters. In addition, social sciences were selected in the search filter to find only education-related articles. The search was completed on February 22, 2022. The researcher did not restrict the publication year when searching the articles in the database. Seventy-eight articles from the SCOPUS database were included in the analysis. The two researchers downloaded and reviewed these articles to assess their suitability for the present study. The review of the suitability of the 78 articles was based on the inclusion and exclusion criteria in **Table 1**. There were no discrepancies in the coding of the articles between the two researchers. Of the articles in the database, only seven were found unsuitable for analysis and therefore excluded from the analysis.

### Data Coding and Analysis

The two researchers coded the articles for analysis, adhering to the inclusion criteria. For the analysis, the researchers created a coding sheet in an Excel program and a framework according to the research questions, determined the codes and coding process, and agreed on the coding and analysis before beginning to analyze the articles individually. The literature agrees that content analysis is a method that involves categorizing, comparing, developing, and organizing theoretical findings (Cohen et al., 2017). The researchers analyzed the articles using the content analysis method. Initially, the researchers coded fifteen articles together using the analysis sheet developed in Excel, and later they continued to code the other articles separately. Both researchers analyzed all the articles according to the analysis criteria. Researchers calculated the inter-rater reliability as 0.91 using Cohen's kappa analysis to determine the inter-rater reliability of the coding process. During the analysis, the researchers discussed subcategories and determined the coding process for those subcategories after the coding process was completed by the researchers separately, a consensus was reached by discussing the codes with which the researchers disagreed.

## RESULTS

Studies addressing motivation in STEM education were first conducted in 2008 (**Figure 1**). In general, the results obtained during the year of the studies showed a remarkable increase in the number of studies on motivation and STEM education.

The results show that the majority (61 articles) of the 71 articles studied were published after 2016. The results show that most of the studies were published in 2021. Based on this result, it can be concluded that a majority number of studies on motivation and STEM have been conducted in recent years. Moreover, the results show the importance of research on motivation and STEM in science education literature.

The results in **Figure 2** show that most studies were conducted in the United States (47.8%), Spain (7%), Turkey (7%), Taiwan (4.2%), Australia (2.8%), China (2.8%), the Netherlands (2.8%), Germany (2.8%), Malaysia (2.8%), and the United Kingdom (2.8%). Only one study on motivation and STEM was completed in other countries, including Belgium, Canada, Indonesia and South Korea, Norway, Russia, the Philippines, Serbia, Slovakia, Vietnam, Sweden, and Switzerland.

**Table 2** shows that the preferred participant groups in studies of motivation and STEM were undergraduates

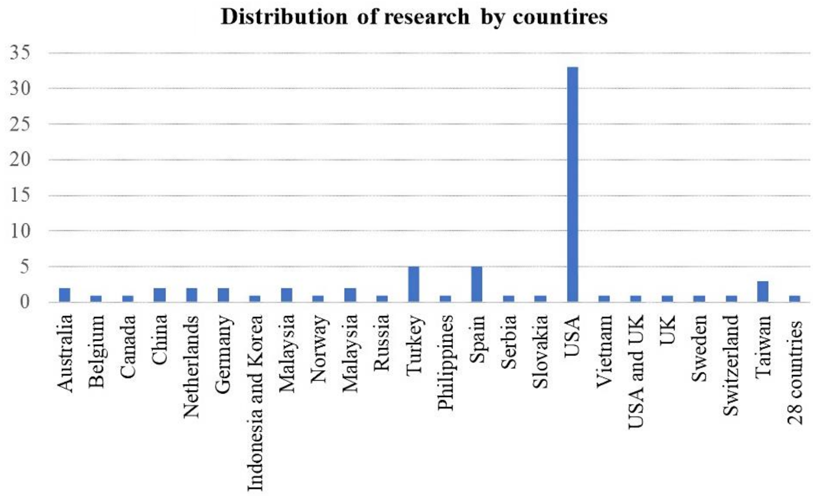


**Figure 2.** Distribution of research by countries (Source: Authors' own elaboration)

**Table 2.** Distribution of participants

| | Frequency | Percentage (%) | Sample research |
|---|---|---|---|
| Elementary | 1 | 1.4 | Asigigan and Samur (2021) |
| Elementary, middle, & high | 1 | 1.4 | Cheng et al. (2020) |
| Elementary, middle, high, & undergraduate | 1 | 1.4 | Hawkins et al. (2019) |
| Faculty members | 4 | 5.6 | Stupnisky et al. (2022) |
| Graduate | 1 | 1.4 | Yang et al. (2018) |
| High school | 19 | 26.7 | Maksimović et al. (2020) |
| High school & teachers | 2 | 2.8 | Fong et al. (2021) |
| Middle | 10 | 14 | Morales-Chicas et al. (2021) |
| Middle & high school | 4 | 5.6 | Vo and Csapó (2023) |
| Parents | 1 | 1.4 | Marotto and Milner-Bolotin (2018) |
| Policy makers | 1 | 1.4 | Wong et al. (2016) |
| Public | 1 | 1.4 | Critchley (2008 |
| Undergraduate | 20 | 28.1 | Tzu-Ling (2019) |
| Undergraduate & graduate | 4 | 5.6 | Rangel et al. (2021) |
| Women | 1 | 1.4 | Schmitt et al. (2021) |

(28.1%), high school students (26.7%), middle school students (14%), faculty members (5.6%), middle and high school students (5.6%), undergraduate and graduate students (5.6%), and high school students and their teachers (2.8%). The other studies were conducted with elementary school students (1.4%), elementary, middle, and high school students (1.4%), elementary, middle, high school, and undergraduate students (1.4%), graduate students (1.4%), parents (1.4%), policymakers (1.4%), the public (1.4%), and women (1.4%), respectively.

The results regarding data collection methods showed that the preferred and most commonly used method was the quantitative research method (**Table 3**). Specifically, 69% of the studies used this method. Studies that used quantitative methods were followed by a mixed method, including quantitative and qualitative methods simultaneously (15.4%). Later, these studies were followed by qualitative methods (14%) among the studies. Among the studies examined, only one study (1.4%, e.g., Shurygin et al., 2023) used an experimental method to examine motivation in STEM education.

**Table 3.** Distribution of research methods

| | F | P (%) | Sample research |
|---|---|---|---|
| Experimental | 1 | 1.4 | Shurygin et al. (2023) |
| Qualitative | 10 | 14.0 | Lechuga (2012). |
| Quantitative | 49 | 69.0 | Kryshko et al. (2022) |
| Quantitative+qualitative | 11 | 15.4 | Talley and Ortiz (2017) |

Note. F: Frequency & P: Percentage

As shown in **Table 4**, the thematic focus of most studies on motivation and STEM was on student-level factors, at 83%. The other thematic foci were teacher-level factors (9.8), instructor-level factors (4.2%), parent-level factors (4.2%), scale/survey development studies (2.8%), adult-level factors (1.4%), model development (1.4%), policymaker-level factors (1.4%), and public-level factors (1.4%). These results show that most of the studies focused on examining the factors of students at all levels regarding motivation variables in STEM education.

Looking at the thematic focuses regarding motivation and STEM studies (**Table 4**), most of the studies included student-level factors (n=59, 83%), such as examining

**Table 4.** Distribution of articles by thematic focus

| | Frequency | Percentage (%) | Sample research |
|---|---|---|---|
| Adult-level factors | 1 | 1.4 | Marotto and Milner-Bolotin (2018) |
| Instructor-level factors | 3 | 4.2 | Bouwma-Gearhart (2012) |
| Model development | 1 | 1.4 | Yahaya et al. (2021) |
| Parent-level factors | 3 | 4.2 | Marotto and Milner-Bolotin (2018) |
| Policy maker factors | 1 | 1.4 | Wong et al. (2016) |
| Public-level factors | 1 | 1.4 | Critchley (2008) |
| Scale/survey development | 2 | 2.8 | De Loof et al. (2021) |
| Student-level factors | 59 | 83 | Yang et al. (2018) |
| Teacher-level factors | 7 | 9.8 | Stupnisky et al. (2022) |

students' motivation regarding STEM (e.g., Gok, 2021; Kuo et al., 2019; Stringer et al., 2020; Yang et al., 2018), the effects of instructional activities on participants' motivation on STEM (Asigigan & Samur, 2021; Chittum et al., 2017; Funa et al., 2021; Higde & Aktamis, 2022; Julià & Antolí, 2019; LaForce et al., 2017; Tsai et al., 2021), investigating the relationships between STEM motivation and related factors (Fong et al., 2021; Gladstone et al., 2022; Hermans et al., 2022; Jeong et al., 2020; Jiang et al., 2020; Vennix et al., 2022). Regarding student-level factors, for example, a study by Dokme et al. (2022) researched the motivation of female preservice teachers toward their STEM fields. Regarding instructional activities, the study by Tsai et al. (2021) examined the effects of a teaching module about marine science on students' motivation, interest, and achievements in marine science. In the studies that investigated the relationships between STEM motivation and related factors, for example, Fong et al. (2021) examined high school students' cross-domain motivation patterns regarding expectancy beliefs and values in mathematics and science in the United States.

These studies were followed by instructors-level factors (Bouwma-Gearhart, 2012; Lechuga, 2012; Richardson et al., 2020), model development (Yahaya et al., 2021), parental attitudes (Marotto & Milner-Bolotin, 2018), public motivation (Critchley, 2008), the purposes of STEM practices among policymakers (Wong et al., 2016), developing a scale (De Loof et al., 2021; Luo et al., 2019), teacher-level factors (Arís & Orcos, 2019; Cheng et al., 2020; Stupnisky et al., 2022). For example, in the study of instructor-level factors, Bouwma-Gearhart (2012) explored the motivations of science and engineering faculty to engage their students at a major research university. In model development, Yahaya et al. (2021) sought to develop an environmental virtual interactive-based teaching model to implement and promote STEM education. Regarding the purposes of STEM practices among policymakers, Wong et al. (2016) asked about the purposes of STEM practices in education to policymakers in England. In the studies on developing data collection tools to measure students' motivation for STEM, Luo et al. (2019) developed a scale to measure students' STEM motivation.

In another line of research, Marotto and Milner-Bolotin (2018) examined parents' attitudes toward STEM education in the level of formal and informal, their motivations for supporting their children, and their views on how schools can support family engagement with STEM. In examining the public's motivation for STEM, Critchley (2008) examined trust in scientists and explored the public's perceived motivation for stem cell researchers. She aimed to explore why the public might be less supportive of stem cell research when the research is conducted in a private setting than in a public research context. Finally, regarding teacher-level factors, the study by Cheng et al. (2020) investigated the effect of teachers' beliefs and 3D printing integration in science classrooms on students' STEM motivation.

## DISCUSSION AND CONCLUSION

This study aimed to determine the current state of research on motivation and STEM and systematically review the current research in the literature. **Appendix A** shows the list of articles used in this systematic review. The results showed that the first research on motivation and STEM were published in 2008. The results also show that researchers did start researching motivation in STEM until after STEM was explained in 2009. The number of studies on motivation and STEM indicates that motivation for encouraging and engaging students in STEM fields is an important research topic in the related STEM literature. Since the results show that most research papers were published in 2021, the popularity of research on motivation in STEM education has increased in recent years. For this reason, future research is expected to focus more on affective factors related to motivation and other related factors or variables in the literature.

The results show that most studies on motivation and STEM were conducted in the United States (47.8%). This result is not interesting because STEM was introduced in the United States. The countries that follow this result are Spain (7%), Turkey (7%), and Taiwan (4.2%). Interestingly, very little research has been done on motivation and STEM education in some developed countries such as Australia (2.8%), China (2.8%), the Netherlands (2.8%), Germany (2.8%), Malaysia (2.8%), and the United Kingdom (2.8%). The results show that further studies are needed in most developed countries and the European Union.

In addition, the results showed that the preferred participant groups were undergraduates (28.1%), high school (26.7%), and middle school students (14%), respectively. The reason for including college students in research studies could be that they have the best chance of finding a job in STEM fields after graduation. Another reason could be that they are an appropriate group of research participants. Another group of research focused on high school students. This result is promising for researchers because high school students are another strong candidate to study STEM fields for undergraduate studies and attend college for higher education in STEM fields. From this perspective, the research results with high school students offer important insights for researchers studying STEM education.

The results show that the researchers used the quantitative method to collect data. Specifically, this method was used in 69% of the research. This method was followed by a mixed method, which included quantitative and qualitative methods (15.4%). Later, qualitative methods followed in these studies (14%). One reason for using the quantitative method in research studies might be that researchers investigated participants' motivation and some relationships between motivation and related variables. Another reason for using the quantitative method may be related to the advantages of quantitative data collection methods, such as the facility to reach larger groups of participants and the ease of administering.

More qualitative researchers should be used in further studies to explore the research questions more deeply profoundly and overcome the complexity of the reasons for educational problems in STEM education. A smaller number of qualitative studies can be considered a research gap in the literature to investigate the relationships between motivation and related variables. On the other hand, the number of research with elementary students could be much higher. Further research should be conducted with this group of participants to raise awareness and encourage attitudes among elementary school students about STEM areas.

The results on the focus of the studies analyzed in this study show that most studies (83%) were conducted to investigate the factors at the student level. This result may be due to the researchers' desire to investigate participants' motivation and the factors influencing their motivation to study STEM fields. Interestingly, less research was found on teacher-level factors. Considering that teachers prepare students for STEM fields, there is a need for more research on teacher-level factors for future research. Moreover, it can be concluded from the results that only two studies (Gok, 2021; Luo et al., 2019) have been conducted to develop an instrument to evaluate and measure scientists' motivation and STEM. Therefore, more research should be conducted to develop instruments to measure and evaluate participants' motivation and STEM.

### Recommendations

This study has limitations and recommendations. First, this study examined only articles in peer-reviewed journals indexed in the SCOPUS database. Articles indexed in the SCOPUS database contain essential insights for researchers in STEM education. However, there is a need for future research to explore other databases such as ERIC, ProQuest, and Web of Science for a similar study. Second, in this study, the authors did not include other documents in the analysis, including book chapters, conference papers, dissertations, and theses. Therefore, further studies should consider including book chapters, conference papers, dissertations, and theses in the analysis. Third, this study has not summarized the main research findings on motivation in STEM education. Therefore, there is a need to comprehensively present the main research findings on motivation in STEM education.

**Author contributions:** All authors have sufficiently contributed to the study and agreed with the results and conclusions.

**Funding:** This paper has been supported by the Kazan Federal University Strategic Academic Leadership Program (PRIORITY-2030).

**Ethical statement:** The authors stated that ethical approval was not required because humans and animals were not used in this literature review. However, ethical guidelines were followed throughout the study.

**Declaration of interest:** No conflict of interest is declared by authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

## REFERENCES

Achilleos, A. P., Mettouris, C., Yeratziotis, A., Papadopoulos, G. A., Pllana, S., Huber, F., Jager, B., Leitner, P., Ocsovszky, Z., & Dinnyés, A. (2019). SciChallenge: A social media aware platform for contest-based STEM education and motivation of young students. *IEEE Transactions on Learning Technologies, 12*(1), 98-111. https://doi.org/10.1109/TLT.2018.2810879

Aeschlimann, B., Herzog, W., & Makarova, E. (2016). How to foster students' motivation in mathematics and science classes and promote students' STEM career choice. A study in Swiss high schools. *International Journal of Educational Research, 79*, 31-41. https://doi.org/10.1016/j.ijer.2016.06.004

Akgunduz, D. (2016). A research about the placement of the top thousand students placed in STEM fields in Turkey between the years 2000 and 2014. *EURASIA Journal of Mathematics, Science and Technology*

*Education, 12*(5), 1365-1377. https://doi.org/10.12973/eurasia.2016.1518a

Andreev, V. V., Gorbunov, V. I., Evdokimova, O. K., & Rimondi, G. (2020). Transdisciplinary approach to improving study motivation among university students of engineering specialties. *Education and Self Development, 15*(1), 21-37. https://doi.org/10.26907/esd15.1.03

Arís, N., & Orcos, L. (2019). Educational robotics in the stage of secondary education: Empirical study on motivation and STEM skills. *Education Sciences, 9*(2), 73. https://doi.org/10.3390/educsci9020073

Asigigan, S. I., & Samur, Y. (2021). The effect of gamified STEM practices on students' intrinsic motivation, critical thinking disposition levels, and perception of problem-solving skills. *International Journal of Education in Mathematics, Science, and Technology, 9*(2), 332-352.https://doi.org/10.46328/ijemst.1157

Belayneh, A.S. (2021). Science teachers' integrative practices in teaching, research, and community services: The case of three universities in Ethiopia. *Education and Self Development, 16*(2), 10-26. https://doi.org/10.26907/esd.16.2.02

Birney, L. B., Evans, B. R., Kong, J., Solanki, V., Mojica, E. R., Scharff, C., Kaoutzanis, D., & Kondapuram, G. (2021). The Billion Oyster project and curriculum and community enterprise for restoration science curriculum impact on underrepresented student motivation to pursue STEM careers. *Journal of Curriculum and Teaching, 10*(4), 47-54. https://doi.org/10.5430/jct.v10n4p47

Bouwma-Gearhart, J. (2012). Research university STEM faculty members' motivation to engage in teaching professional development: Building the choir through an appeal to extrinsic motivation and ego. *Journal of Science Education and Technology, 21*, 558-570. https://doi.org/10.1007/s10956-011-9346-8

Cheng, L., Antonenko, P. D., Ritzhaupt, A. D., Dawson, K., Miller, D., MacFadden, B. J., Grant, C., Sheppard, T. D., & Ziegler, M. (2020). Exploring the influence of teachers' beliefs and 3D printing integrated STEM instruction on students' STEM motivation. *Computers & Education, 158*, 103983. https://doi.org/10.1016/j.compedu.2020.103983

Chittum, J. R., Jones, B. D., Akalin, S., & Schram, A. B. (2017). The effects of an afterschool STEM program on students' motivation and engagement. *International Journal of STEM Education, 4*, 11. https://doi.org/10.1186/s40594-017-0065-4

Critchley, C. R. (2008). Public opinion and trust in scientists: The role of the research context, and the perceived motivation of stem cell researchers. *Public Understanding of Science, 17*(3), 309-327. https://doi.org/10.1177/0963662506070162

De Loof, H., Struyf, A., Boeve-de Pauw, J., & Van Petegem, P. (2021). Teachers' motivating style and students' motivation and engagement in STEM: The relationship between three key educational concepts. *Research in Science Education, 51*, 109-127. https://doi.org/10.1007/s11165-019-9830-3

Dokme, I., Aciksoz, A., & Koyunlu Unlu, Z. (2022). Investigation of STEM fields motivation among female students in science education colleges. *International Journal of STEM Education, 9*(1), 8. https://doi.org/10.1186/s40594-022-00326-2

Donmez, I., Idin, S., & Gurbuz, S. (2022). Determining lower-secondary students' STEM motivation: A profile from Turkey. *Journal of Baltic Science Education, 21*(1), 38-51. https://doi.org/10.33225/jbse/22.21.38

Fiorella, L., Yoon, S. Y., Atit, K., Power, J. R., Panther, G., Sorby, S., Uttal, D. H., & Veurink, N. (2021). Validation of the mathematics motivation questionnaire (MMQ) for secondary school students. *International Journal of STEM Education, 8*, 52. https://doi.org/10.1186/s40594-021-00307-x

Fong, C. J., Kremer, K. P., Cox, C. H. T., & Lawson, C. A. (2021). Expectancy-value profiles in math and science: A person-centered approach to cross-domain motivation with academic and STEM-related outcomes. *Contemporary Educational Psychology, 65*, 101962. https://doi.org/10.1016/j.cedpsych.2021.101962

Freeman, K. E., Alston, S. T., & Winborne, D. G. (2008). Do learning communities enhance the quality of students' learning and motivation in STEM? *The Journal of Negro Education, 77*(3), 227-240.

Funa, A. A., Gabay, R. A. E., & Ricafort, J. D. (2021). Gamification in genetics: Effects of gamified instructional materials on the STEM students' intrinsic motivation. *Jurnal Pendidikan IPA Indonesia* [*Journal of Indonesian Science Education*], *10*(4), 462-473. https://doi.org/10.15294/jpii.v10i4.32143

Gladstone, J. R., Morell, M., Yang, J. S., Ponnock, A., Turci Faust, L., & Wigfield, A. (2022). You can't compare if you don't prepare: Differential item functioning in measures of grit, stem self-regulation, and motivation. *The Journal of Experimental Education*. https://doi.org/10.1080/00220973.2022.2062584

Gok, T. (2021). The development of the STEM (science, technology, engineering, and mathematics) attitude and motivation survey towards secondary school students. *International Journal of Cognitive Research in Science, Engineering and Education, 9*(1), 105-119. https://doi.org/10.23947/2334-8496-2021-9-1-105-119

Hasanah, U. (2020). Key definitions of STEM education: Literature review. *Interdisciplinary Journal of*

*Environmental and Science Education, 16*(3), e2217. https://doi.org/10.29333/ijese/8336

Hawkins, I., Ratan, R., Blair, D., & Fordham, J. (2019). The effects of gender role stereotypes in digital learning games on motivation for STEM achievement. *Journal of Science Education and Technology, 28*, 628-637. https://doi.org/10.1007/s10956-019-09792-w

Hermans, S., Gijsen, M., Mombaers, T., & Van Petegem, P. (2022). Gendered patterns in students' motivation profiles regarding iSTEM and STEM test scores: A cluster analysis. *International Journal of STEM Education, 9*(1), 67. https://doi.org/10.1186/s40594-022-00379-3

Hernandez, P. R., Schultz, P. W., Estrada, M., Woodcock, A., & Chance, R. C. (2013). Sustaining optimal motivation: A longitudinal analysis of interventions to broaden participation of underrepresented students in STEM. *Journal of Educational Psychology, 105*(1), 89-107. https://doi.org/10.1037/a0029691

Higde, E., & Aktamis, H. (2022). The effects of STEM activities on students' STEM career interests, motivation, science process skills, science achievement and views. *Thinking Skills and Creativity, 43*, 101000. https://doi.org/10.1016/j.tsc.2022.101000

Hsieh, T. L., & Yu, P. (2022). Exploring achievement motivation, student engagement, and learning outcomes for STEM college students in Taiwan through the lenses of gender differences and multiple pathways. *Research in Science & Technological Education*. https://doi.org/10.1080/02635143.2021.1983796

Hsu, J. L., Rowland-Goldsmith, M., & Schwartz, E. B. (2022). Student motivations and barriers toward online and in-person office hours in STEM courses. *CBE–Life Sciences Education, 21*(4), ar68. https://doi.org/10.1187/cbe.22-03-0048

Jeffries, D., Curtis, D. D., & Conner, L. N. (2020). Student factors influencing STEM subject choice in year 12: A structural equation model using PISA/LSAY data. *International Journal of Science and Mathematics Education, 18*, 441-461. https://doi.org/10.1007/s10763-019-09972-5

Jensen, F., & Sjaastad, J. A. (2013). Norwegian out-of-school *mathematics* project's influence on secondary students' STEM motivation. *International Journal of Science and Mathematics Education, 11*, 1437-1461. https://doi.org/10.1007/s10763-013-9401-4

Jeong, J. S., González-Gómez, D., & Prieto, F. Y. (2020). Sustainable and flipped STEM education: Formative assessment online interface for observing pre-service teachers' performance and motivation. *Education Sciences, 10*(10), 283. https://doi.org/10.3390/educsci10100283

Jiang, S., Simpkins, S. D., & Eccles, J. S. (2020). Individuals' math and science motivation and their subsequent STEM choices and achievement in high school and college: A longitudinal study of gender and college generation status differences. *Developmental Psychology, 56*(11), 2137-2151. https://doi.org/10.1037/dev0001110

Julià, C., & Antolí, J. Ò. (2019). Impact of implementing a long-term STEM-based active learning course on students' motivation. *International Journal of Technology and Design Education, 29*, 303-327. https://doi.org/10.1007/s10798-018-9441-8

Jungert, T., Levine, S., & Koestner, R. (2020) Examining how parent and teacher enthusiasm influences motivation and achievement in STEM. *The Journal of Educational Research, 113*(4), 275-282. https://doi.org/10.1080/00220671.2020.1806015

Klebanov, B., Burstein, J., Harackiewicz, J.M., Priniski, S. J., & Mulholland, M. (2017). Reflective writing about the utility value of science as a tool for increasing STEM motivation and retention–Can AI help scale up? *International Journal of Artificial Intelligence in Education, 27*, 791-818. https://doi.org/10.1007/s40593-017-0141-4

Kryshko, O., Fleischer, J., Grunschel, C., & Leutner, D. (2022). Self-efficacy for motivational regulation and satisfaction with academic studies in STEM undergraduates: The mediating role of study motivation. *Learning and Individual Differences, 93*, 102096. https://doi.org/10.1016/j.lindif.2021.102096

Kuo, H.-C., Tseng, Y.-C., & Yang, Y.-T. C. (2018). Promoting college student's learning motivation and creativity through a STEM interdisciplinary PBL human-computer interaction system design and development course. *Thinking Skills and Creativity, 31*, 1-10. https://doi.org/10.1016/j.tsc.2018.09.001

LaForce, M., Noble, E., & Blackwell, C. (2017). Problem-based learning (PBL) and student interest in STEM careers: The roles of motivation and ability beliefs. *Education Sciences, 7*(4), 92. https://doi.org/10.3390/educsci7040092

Leaper, C., & Starr, C. R. (2018). Helping and hindering undergraduate women's STEM motivation. *Psychology of Women Quarterly, 43*(2), 165-183. https://doi.org/10.1177/0361684318806302

Lechuga, V. M. (2012). Latino faculty in STEM disciplines: Motivation to engage in research activities. *Journal of Latinos and Education, 11*(2), 107-123. https://doi.org/10.1080/15348431.2012.659564

León, J., Núñez, J. L., & Liew, J. (2015). Self-determination and STEM education: Effects of autonomy, motivation, and self-regulated learning on high school math achievement. *Learning and Individual Differences, 43*, 156-163. https://doi.org/10.1016/j.lindif.2015.08.01710.1016/j.lindif.2015.08.017

Luo, T., Wang, J., Liu, X., & Zhou, J. (2019). Development and application of a scale to measure students' STEM continuing motivation. *International Journal of Science Education, 41*(14), 1885-1904. https://doi.org/10.1080/09500693.2019.1647472

Maksimović, J. Ž., Osmanović, J. S., & Mamutović, A. S. (2020). Perspectives of STEM education regarding Serbian secondary school students' motivation for career choice. *Journal of Baltic Science Education, 19*(6), 989-1007. https://doi.org/10.33225/jbse/20.19.989

Marotto, C. C., & Milner-Bolotin, M. (2018). Parental engagement in children's STEM education. Part II: Parental attitudes and motivation. *LUMAT: International Journal on Math, Science and Technology Education, 6*(1), 60-86. https://doi.org/10.31129/LUMAT.6.1.293

Martynenko, O. O., Pashanova, O. V., Korzhuev, A. V., Prokopyev, A. I., Sokolova, N. L., & Sokolova, E. G. (2023). Exploring attitudes towards STEM education: A global analysis of university, middle school, and elementary school perspectives. *EURASIA Journal of Mathematics, Science and Technology Education, 19*(3), em2234. https://doi.org/10.29333/ejmste/12968

Morales-Chicas, J., Ortiz, J., Tanimura, D. M., & Kouyoumdjian, C. (2021). Understanding Latino boys' motivation to pursue STEM while navigating school inequalities. *Journal of Latinos and Education*. https://doi.org/10.1080/15348431.2021.1944864

Morgan, A., Smaldone, D., Selin, S., Deng, J., & Holmes, M. (2022). Adding relevancy to STEM interest through adventure education: A mixed methods study. *Interdisciplinary Journal of Environmental and Science Education, 18*(4), e2294. https://doi.org/10.21601/ijese/12214

Mulvey, K. L., McGuire, L., Mathews, C., Hoffman, A. J., Law, F., Joy, A., Hartstone-Rose, A., Winterbottom, M., Balkwill, F., Fields, G., Butler, L., Burns, K., Drews, M., & Rutland, A. (2022). Preparing the next generation for STEM: Adolescent profiles encompassing math and science motivation and interpersonal skills and their associations with identity and belonging. *Youth & Society, 0*(0). https://doi.org/10.1177/0044118X221085296

Murphy, S., MacDonald, A., Wang, C. A., & Danaia, L. (2019). Towards an understanding of STEM engagement: A review of the literature on motivation and academic emotions. *Canadian Journal of Science, Mathematics and Technology Education, 19*, 304-320. https://doi.org/10.1007/s42330-019-00054-w

National Science & Technology Council. (2013). Federal science, technology, engineering and mathematics (STEM) education: 5-year strategic plan. *National Archives*. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

Ng, W. (2020). Affective profiles of year 9/10 Australian and Southeast Asian students in science and science education. *EURASIA Journal of Mathematics, Science and Technology Education, 16*(1), em1804. https://doi.org/10.29333/ejmste/110782

Parks, M. B., Hendryx, E. P., & Taylor, A. T. (2021). The study of stream litter accumulation as a model for cross-disciplinary, transformative, affordable, and scalable undergraduate research experiences in STEM. *Interdisciplinary Journal of Environmental and Science Education, 17*(3), e2245. https://doi.org/10.21601/ijese/10935

Pitt, R. N., Brockman, A., & Zhu, L. (2021). Parental pressure and passion: Competing motivations for choosing STEM and non-STEM majors among women who double-major in both. *Journal of Women and Minorities in Science and Engineering, 27*(1), 1-29. https://doi.org/10.1615/JWomenMinorScienEng.2020026795

Rangel, V. S., Jones, S., Doan, V., Henderson, J., Greer, R., & Manuel, M. (2021). The motivations of STEM mentors. *Mentoring & Tutoring: Partnership in Learning, 29*(4), 353-388. https://doi.org/10.1080/13611267.2021.1954461

Razali, F., Manaf, U. K. A., Talib, O., & Hassan, S. A. (2020). Motivation to learn science as a mediator between attitude towards STEM and the development of stem career aspiration among secondary school students. *Universal Journal of Educational Research, 8*(1), 138-146. https://doi.org/10.13189/ujer.2020.081318

Richardson, D. S., Bledsoe, R. S., & Cortez, Z. (2020). Mindset, motivation, and teaching practice: Psychology applied to understanding teaching and learning in STEM disciplines. *CBE–Life Sciences Education, 19*(3), ar46. https://doi.org/10.1187/cbe.19-11-0238

Ritz, J. M., & Fan, S. C. (2015). STEM and technology education: international state-of-the-art. *International Journal of Technology and Design Education, 25*, 429-451. https://doi.org/10.1007/s10798-014-9290-z

Robnett, R. D., & Leaper, C. (2012). Friendship groups, personal motivation, and gender in relation to high school students' STEM career interest. *Journal of*

*Research on Adolescence, 23*(4), 652-664. https://doi.org/10.1111/jora.12013

Roungos, G., Kalloniatis, C., & Matsinos, V. (2020). STEAM education in Europe and the PISA test. *Scientific Educational Journal, 8*(3), 177-187.

Sáinz, M., Fàbregues, S., Rodó-de-Zárate, M., Martínez-Cantos, J.-L., Arroyo, L., & Romano, M.-J. (2018). Gendered motivations to pursue male-dominated STEM careers among Spanish young people. *Journal of Career Development, 47*(4), 408-423. https://doi.org/10.1177/0894845318801101

Saleh, S., Ashari, Z. M., Kosnin, A. M., & Rahmani, A. S. (2019). A systematic literature review on the roles of interest and motivation in STEM education. 2019 In *Proceedings of the IEEE International Conference on Engineering, Technology and Education* (pp. 1-6). https://doi.org/10.1109/tale48000.2019.9225997

Salsa, F. J., Sari, R. T., Muhar, N., & Gusmaweti, G. (2022). The relationship between motivation and learning outcomes of biology subject through distance learning. *International Journal of STEM Education for Sustainability, 2*(2), 140-147. https://doi.org/10.53889/ijses.v2i2.54

Shchemeleva, Y. B. (2020). Early career guidance as a method of developing the foundations of engineering thinking. *Education and Self Development, 15*(4), 127-136. https://doi.org/10.26907/esd15.4.12

Schmitt, M., Lauer, S., & Wilkesmann, U. (2021). Work motivation and career autonomy as predictors of women's subjective career success in STEM. *Acta Paedagogica Vilnensia, 46*, 73-89. https://doi.org/10.15388/ActPaed.2021.46.5

Schnittka, C. G., Brandt, C. B., Jones, B. D., & Evans, M. A. (2012). Informal engineering education after school: Employing the studio model for motivation and identification in STEM domains. *Advances in Engineering Education, 3*(2), 1-31.

Shin, S., Rachmatullah, A., Roshayanti, F., Ha, M., & Lee, J. K. (2018). Career motivation of secondary students in STEM: A cross-cultural study between Korea and Indonesia. *International Journal for Educational and Vocational Guidance, 18*, 203-231. https://doi.org/10.1007/s10775-017-9355-0

Shurygin, V., Anisimova, T., Orazbekova, R., & Pronkin, N. (2023). Modern approaches to teaching future teachers of mathematics: The use of mobile applications and their impact on students' motivation and academic success in the context of STEM education. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2022.2162548

Solanki, S. M., & Xu, D. (2018). Looking beyond academic performance: The influence of instructor gender on student motivation in STEM fields. *American Educational Research Journal, 55*(4), 801-835. https://doi.org/10.3102/0002831218759034

Starr, C. R. (2018). "I'm not a science nerd!": STEM stereotypes, identity, and motivation among undergraduate women. *Psychology of Women Quarterly, 42*(4), 489-503. https://doi.org/10.1177/0361684318793848

Starr, C. R., & Leaper, C. (2019). Do adolescents' self-concepts moderate the relationship between STEM stereotypes and motivation? *Social Psychology of Education, 22*, 1109-1129. https://doi.org/10.1007/s11218-019-09515-4

Starr, C. R., Anderson, B. R., & Green, K. A. (2019). "I'm a computer scientist!": Virtual reality experience influences stereotype threat and STEM motivation among undergraduate women. *Journal of Science Education and Technology, 28*, 493-507. https://doi.org/10.1007/s10956-019-09781-z

Starr, C. R., Hunter, L., Dunkin, R., Honig, S., Palomino, R., & Leaper, C. (2020). Engaging in science practices in classrooms predicts increases in undergraduates' STEM motivation, identity, and achievement: A short-term longitudinal study. *Journal of Research in Science Teaching, 57*(7), 1093-1118. https://doi.org/10.1002/tea.21623

Stolk, J. D., Gross, M. D., & Zastavker, Y. V. (2021). Motivation, pedagogy, and gender: Examining the multifaceted and dynamic situational responses of women and men in college STEM courses. *International Journal of STEM Education, 8*(1), 35. https://doi.org/10.1186/s40594-021-00283-2

Stringer, K., Mace, K., Clark, T., & Donahue, T. (2020). STEM focused extracurricular programs: Who's in them and do they change STEM identity and motivation? *Research in Science & Technological Education, 38*(4), 507-522. https://doi.org/10.1080/02635143.2019.1662388

Stupnisky, R. H., Larivière, V., Hall, N. C., & Omojiba, O. (2022). Predicting research productivity in STEM faculty: The role of self-determined motivation. *Research in Higher Education*. https://doi.org/10.1007/s11162-022-09718-3

Svoboda, R. C., Rozek, C. S., Hyde, J. S., Harackiewicz, J. M., & Destin, M. (2016). Understanding the relationship between parental education and STEM course taking through identity-based and expectancy-value theories of motivation. *Aera Open, 2*(3). https://doi.org/10.1177/2332858416664875

Talley, K. G., & Ortiz, A. M. (2017). Women's interest development and motivations to persist as college students in STEM: A mixed methods analysis of views and voices from a Hispanic-Serving Institution. *International Journal of STEM Education, 4*, 5. https://doi.org/10.1186/s40594-017-0059-2

Tawbush, R. L., Stanley, S. D., Campbell, T. G., & Webb, M. A. (2020). International comparison of K-12 STEM teaching practices. *Journal of Research in Innovative Teaching & Learning, 13*(1), 115-128. https://doi.org/10.1108/JRIT-01-2020-0004

Tomšik, R., & Cerešník, M. (2017). Differences in motivation of choosing teaching as a profession among teacher trainees of STEM and non-STEM study programs. *TEM Journal, 6*(2), 400.

Totonchi, D. A., Perez, T., Lee, Y. K., Robinson, K. A., & Linnenbrink-Garcia, L. (2021). The role of stereotype threat in ethnically minoritized students' science motivation: A four-year longitudinal study of achievement and persistence in STEM. *Contemporary Educational Psychology, 67*, 102015. https://doi.org/10.1016/j.cedpsych.2021.102015

Tsai, L.-T., Chang, C.-C., & Cheng, H.-T. (2021). Effect of a stem-oriented course on students' marine science motivation, interest, and achievements. *Journal of Baltic Science Education, 20*(1), 134-145. https://doi.org/10.33225/jbse/21.20.134

Tzu-Ling, H. (2019). Gender differences in high-school learning experiences, motivation, self-efficacy, and career aspirations among Taiwanese STEM college students. *International Journal of Science Education, 41*(13), 1870-1884. https://doi.org/10.1080/09500693.2019.1645963

Vennix, J., den Brok, P., & Taconis, R. (2022). Motivation style of K-12 students attending outreach activities in the STEM field: A person-based approach. *Learning Environments Research, 26*, 129-143. https://doi.org/10.1007/s10984-022-09407-z

Vo, D. V., & Csapó, B. (2023). Exploring inductive reasoning, scientific reasoning and science motivation and their role in predicting STEM achievement across grade levels. *International Journal of Science and Mathematics Education*. https://doi.org/10.1007/s10763-022-10349-4

Wang, X. (2013). Why students choose STEM majors. *American Educational Research Journal, 50*(5), 1081-1121. https://doi.org/10.3102/0002831213488622

White House Office of the Press Secretary. (2009). *President Obama launches "educate to innovate" campaign for excellence in science, technology, engineering & math (STEM) education* [Press release]. https://obamawhitehouse.archives.gov/the-press-office/president-obama-launches-educate-innovate-campaign-excellence-science-technology-en

Wong, V., Dillon, J., & King, H. (2016). STEM in England: Meanings and motivations in the policy arena. *International Journal of Science Education, 38*(15), 2346-2366. https://doi.org/10.1080/09500693.2016.1242818

Yahaya, J., Fadzli, S., Deraman, A., Yahaya, N. Z., Halim, L., Rais, I. A. I., & Ibrahim, S. R. A. (2021). PRInK: Environmental virtual interactive based education and learning model for STEM motivation. *Education and Information Technologies, 27*, 4771-4791. https://doi.org/10.1007/s10639-021-10794-8

Yang, X., & Gao, C. (2021). Missing women in STEM in China: An empirical study from the viewpoint of achievement motivation and gender socialization. *Research in Science Education, 51*, 1705-1723. https://doi.org/10.1007/s11165-019-9833-0

Yang, Y., Volet, S., & Mansfield, C. (2018). Motivations and influences in Chinese international doctoral students' decision for STEM study abroad. *Educational Studies, 44*(3), 264-278. https://doi.org/10.1080/03055698.2017.1347498

## APPENDIX A

**Table A1.** List of articles used in the systematic review

| Authors | Year | Country | Sample level | Method | Thematic focus |
|---|---|---|---|---|---|
| Vo and Csapó (2023) | 2023 | Vietnam | Middle & high school | Quantitative | Student-level factors |
| Shurygin et al. (2023) | 2023 | Russia | Undergraduate | Experimental | Student-level factors |
| Hermans et al. (2022) | 2022 | Netherlands | Middle | Quantitative | Student-level factors |
| Hsu et al. (2022) | 2022 | USA | Undergraduate | Quantitative | Student-level factors |
| Dokme et al. (2022) | 2022 | Turkey | Undergraduate | Quantitative | Student-level factors |
| Yahaya et al. (2021) | 2021 | Malaysia | Secondary school | Quantitative | Model development |
| Higde and Aktamis (2022) | 2022 | Turkey | Middle | Quantitative | Student-level factors |
| Stupnisky et al. (2022) | 2022 | USA | Faculty members | Quantitative | Teacher-level factors |
| Gladstone et al. (2022) | 2022 | USA | High school | Quantitative | Student-level factors |
| Mulvey et al. (2022) | 2022 | USA & UK | High school | Quantitative | Student-level factors |
| Donmez et al. (2022) | 2022 | Turkey | Middle | Quantitative | Student-level factors |
| Vennix et al. (2022) | 2023 | Netherlands | Middle & high school | Quantitative | Student-level factors |
| Hsieh and Yu (2022) | 2022 | Taiwan | Undergraduate | Quantitative | Student-level factors |
| Kryshko et al. (2022) | 2022 | Germany | Undergraduate | Quantitative | Student-level factors |
| Funa et al. (2021) | 2021 | Philippines | High school | Quantitative | Student-level factors |
| Stolk et al. (2021) | 2021 | USA | Undergraduate | Quantitative | Student-level factors |
| Yang and Gao (2021) | 2021 | China | Undergraduate | Quantitative | Student-level factors |
| Totonchi et al. (2021) | 2021 | USA | Undergraduate | Quantitative | Student-level factors |
| De Loof et al. (2021) | 2021 | Belgium | High school | Quantitative & qualitative | Teacher- & student-level factors |
| Fong et al. (2021) | 2021 | USA | High school & teachers | Quantitative & qualitative | Teacher- & student-level factors |
| Birney et al. (2021) | 2021 | USA | High school | Quantitative | Student-level factors |
| Schmitt et al. (2021) | 2021 | Germany | Women | Quantitative | Adult-level factors |
| Rangel et al. (2021) | 2021 | USA | Undergraduate & graduate | Qualitative | Teacher-level factors |
| Morales-Chicas et al. (2021) | 2021 | USA | Middle | Qualitative | Student-level factors |
| Gok (2021). | 2021 | Turkey | High school | Quantitative | Survey development |
| Asigigan and Samur (2021) | 2021 | Turkey | Elementary | Quantitative & qualitative | Student-level factors |
| Pitt et al. (2021) | 2021 | USA | Undergraduate | Quantitative | Student-level factors |
| Tsai et al. (2021) | 2021 | Taiwan | High school | Quantitative | Student-level factors |
| Cheng et al. (2020) | 2020 | USA | Elementary, middle, & high | Quantitative | Teacher- & student-level factors |
| Jeong et al. (2020) | 2020 | Spain | Pre-service teachers | Quantitative & qualitative | Student-level factors |
| Stringer et al. (2020) | 2020 | USA | Middle | Quantitative | Student-level factors |
| Starr et al. (2020) | 2020 | USA | Undergraduate | Quantitative | Student-level factors |
| Jungert et al. (2020) | 2020 | Sweden | High school | Quantitative | Student- & parent-level factors |
| Sáinz et al. (2020) | 2020 | Spain | Undergraduate & graduate | Qualitative | Student- & graduate-level factors |
| Maksimović et al. (2020) | 2020 | Serbia | High school | Quantitative & qualitative | Student-level factors |
| Jiang et al. (2020) | 2020 | USA | High school | Quantitative | Student-level factors |
| Richardson et al. (2020) | 2020 | USA | Instructors | Quantitative | Instructor-level factors |
| Razali et al. (2020) | 2020 | Malaysia | High school | Quantitative | Student-level factors |
| Hawkins et al. (2019) | 2019 | USA | Elementary, middle, high, & undergraduate | Quantitative | Student-level factors |
| Starr and Leaper (2019) | 2019 | USA | High school | Quantitative | Student-level factors |
| Starr et al. (2019) | 2019 | USA | Undergraduate | Quantitative | Student-level factors |
| Luo et al. (2019) | 2019 | China | Middle | Quantitative | Scale development |
| Arís and Orcos (2019) | 2019 | Spain | High school & teachers | Quantitative | Teacher- & student-level factors |
| Leaper and Starr (2018) | 2018 | USA | Undergraduate | Quantitative | Student-level factors |
| Julià and Antolí (2019) | 2019 | Spain | Middle | Quantitative | Student-level factors |

**Table A1 (Continued).** List of articles used in the systematic review

| Authors | Year | Country | Sample level | Method | Thematic focus |
|---|---|---|---|---|---|
| Kuo et al. (2019) | 2019 | Taiwan | Undergraduate & graduate | Quantitative & qualitative | Student-level factors |
| Tzu-Ling (2019) | 2019 | Taiwan | Undergraduate | Quantitative | Student-level factors |
| Achilleos et al. (2019) | 2019 | 28 countries | Middle | Quantitative | Student-level factors |
| Starr (2018) | 2018 | USA | Undergraduate | Quantitative | Student-level factors |
| Solanki and Xu (2018) | 2018 | USA | Undergraduate | Quantitative | Teacher- & student-level factors |
| Shin et al. (2018) | 2018 | Indonesia & Korea | Middle & High school | Quantitative | Student-level factors |
| Yang et al. (2018) | 2018 | Australia | Graduate | Qualitative | Student-level factors |
| Marotto and Milner-Bolotin (2018) | 2018 | Canada | Parents | Qualitative | Parent-level factors |
| LaForce et al. (2017) | 2017 | USA | High school | Quantitative | Student-level factors |
| Chittum et al. (2017) | 2017 | USA | Middle | Quantitative & qualitative | Student-level factors |
| Klebanov et al. (2017) | 2017 | USA | Undergraduate | Qualitative | Student-level factors |
| Talley and Ortiz (2017) | 2017 | USA | Undergraduate | Quantitative & qualitative | Student-level factors |
| Tomšik and Cerešník (2017) | 2017 | Slovakia | Undergraduate | Quantitative | Student-level factors |
| Wong et al. (2016) | 2016 | UK | Policy makers | Qualitative | Policy maker factors |
| Svoboda et al. (2016) | 2016 | USA | Middle & high school & parents | Quantitative | Student- & parent-level factors |
| Aeschlimann et al. (2016) | 2016 | Switzerland | High school | Quantitative | Student-level factors |
| León et al. (2015) | 2015 | Spain | High school | Quantitative | Student-level factors |
| Jensen and Sjaastad (2013) | 2013 | Norway | High school | Quantitative & qualitative | Student-level factors |
| Robnett and Leaper (2012) | 2012 | USA | High school | Quantitative | Student-level factors |
| Wang (2013) | 2013 | USA | High school | Quantitative | Student-level factors |
| Hernandez et al. (2013) | 2013 | USA | Undergraduate & graduate | Quantitative | Student-level factors |
| Schnittka et al. (2012) | 2012 | USA | Middle | Quantitative & qualitative | Student-level factors |
| Bouwma-Gearhart (2012) | 2012 | USA | Faculty members | Qualitative | Instructor-level factors |
| Lechuga (2012) | 2012 | USA | Faculty members | Qualitative | Instructor-level factors |
| Critchley (2008) | 2008 | Australia | Public | Qualitative | Public-level factors |
| Freeman et al. (2008) | 2008 | USA | Undergraduate | Quantitative & qualitative | Student-level factors |