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RESEARCH ARTICLE

What Makes Students Engage in Science: Is It Universal?

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Abstract
This study aims to investigate middle school students' engagement in science from an international perspective. In the light of the expectancy–value theory of achievement-related behaviors, students' gender, socio-economic status, self-efficacy, and task value (utility value and intrinsic value) were handled as predictors of science engagement. The data were gathered from Trends in International Mathematics and Science Study (2015). The participants of this study were eighth-grade middle school students from 30 different countries. A logistic regression analysis was conducted to investigate how the combination of mentioned variables predicts students' science engagement. According to the results, students' task value beliefs have the highest contribution to the model. Besides, other findings were discussed in consideration of differences among countries.

Keywords: Engagement, science education, self-efficacy, task value, TIMSS

Introduction

Nowadays, student engagement is an outstanding topic for educational researchers (Eccles & Wang, 2012) since it is associated with positive student outcomes (Fredricks et al., 2004). For instance, it is suggested that classroom engagement supports students' science learning; it is important for developing students' reasoning and deep understanding of science (Pugh et al., 2010; Ryu & Lombardi, 2015). Besides that, middle school students' engagement in science and math plays an important role in students pursuing a career related to science, technology, engineering, and mathematics (STEM) fields (Maltese & Tai, 2010).

Skinner and Pitzer (2012) define engagement as "the manifestation of motivation." According to them, engagement makes a person's motivation visible. Namely, while motivation concerns energy and purpose of the action, engagement concerns the sign of the energy; engagement is the outpouring of individuals' motivation. Reschly and Christenson (2012) draw an analogy between the glue and engagement; it bridges the gap between the context and interest of students. Engagement is a multidimensional construct. Although there are different classifications of engagement in the relevant literature, it can mainly

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be organized into three types: behavioral, emotional, and cognitive. Behavioral engagement concerns students' participation, effort, and persistence in the task. Secondly, emotional engagement concerns students' positive or negative effects on the task. Lastly, cognitive engagement concerns students' self-regulation or personal investment in the task (Fredricks et al., 2004). By engagement's nature, it has always been at the center of the motivational theories (Skinner & Pitzer, 2012). Besides, Eccles and Wang (2012) underline that students' engagement can be explained by their individual motivations and it can also be handled as an outcome of expectancy-value theory.

Expectancy–Value Theory of Engagement

Eccles et al. (1983) proposed an expectancy–value theoretical (EVT) model to explain the underlying reasons for individuals' achievement-related activities and their performance. In their model, the outcome is achievement-related behaviors; however, engagement can also take place in the scope of EVT's outcome. Expectancy–value theoretical model researchers suggest that students' beliefs about their capacity and the value of the activity for them can explain their performance-related behaviors (Wigfield & Eccles, 1994). Namely, according to the EVT model, two main motivational constructs affect students' engagement: task value and expectancy beliefs. Moreover, students' demographic features such as gender or family characteristics are also important factors to determine their achievement-related choices. Furthermore, Eccles and Wang (2012) explained that students' engagement can be included as a dependent variable in the model. They also remarked that the engagement type to be included in the EVT model can be both cognitive engagement and behavioral engagement. Hence, in this study, EVT was considered while investigating antecedents of student engagement. The general model of EVT is presented in Figure 1.

Motivational Beliefs and Engagement

According to the EVT model, students' expectancies about the task and their task value beliefs directly affect students' engagement. In other words, according to the theory, two main motivational constructs, expectations of success and task value, are the main precursors of engagement (Eccles & Wang, 2012). The expectation of success refers to students' beliefs about how well they perform while doing the task (Wigfield & Eccles, 1992). Wigfield and Eccles (2000) explain that these beliefs are related to students' expectations, not their expectations for outcome. Thus, the expectancy of success is a bit similar to Bandura's self-efficacy construct. Moreover, expectancy–value theorists also assess students' expectancies of success in the same manner as self-efficacy. For this reason, in this study, students' self-efficacy beliefs represent the expectancy of success construct of EVT. Self-efficacy can be defined

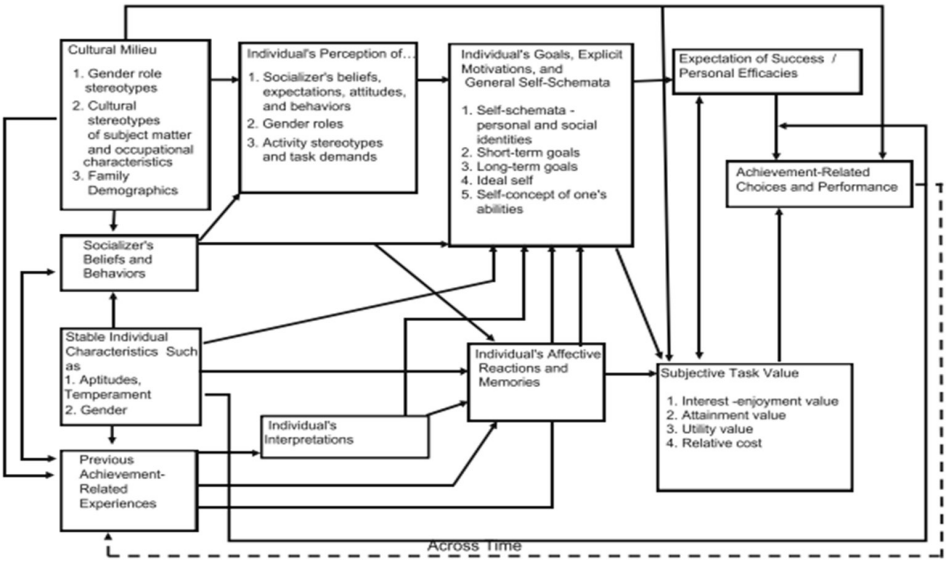

Figure 1.
The General Model of Expectancy–Value Theory. Reprinted From Handbook of Research on Student Engagement (p. 143), by Christenson et al. (2012), Springer.

as individuals' beliefs about whether they can achieve the given task or not. In other words, it is their self-evaluation about the performance in the upcoming task (Bandura, 1977). Students' self-efficacy beliefs are important contributors to their achievement-related behaviors (Schunk et al., 2010). According to the relevant research, students who have strong self-efficacy beliefs tend to show effort, persistence during the task; namely, they show more engagement than their peers who are low self-efficacious (Hoy, 2004; Linnenbrink & Pintrich, 2003).

The other important motivational construct of EVT is task value, which refers to their beliefs about how the task meets their needs (Eccles et al., 1983; Wigfield & Eccles, 1992). Task value has four components: attainment value, intrinsic value, utility value, and cost. First and foremost, attainment concerns the significance of the task. While intrinsic value refers to the enjoyment of the task, utility value refers to the benefits of the task, whether the task will help students' future goals or not. Lastly, the cost is related to the limitations of engaging in a task. To explain the cost component in detail, while individuals choose to engage in a task, they give up the other choices. Evaluation of these possibilities shows the cost of the task (Wigfield & Eccles, 2000). According to the EVT model, students' task value beliefs are directly linked to their achievement-related behaviors like engagement (Eccles & Wang, 2012; Eccles et al., 1983). In other words, students who find the task interesting, useful, or important tend to engage in the task more than their peers who have low task value beliefs (Cole et al., 2008).

To exemplify the studies about the link between motivational beliefs and engagement, Linnenbrink-Garcia et al. (2018) made a classification to investigate students' motivational profiles and how these profiles related to academic outcomes. They identified the following three profiles: moderate-high all, intrinsic and confident, and average all motivation. The intrinsic and confident group had higher levels of self-efficacy and task value beliefs than the other groups. According to the results, students who were in the intrinsic and confident group showed high engagement. In another study, Bae and DeBusk-Lane (2019) examined students' engagement under five groups: moderately engaged, moderately disengaged, disengaged, behaviorally engaged, and behaviorally disengaged. The groups were created by considering multi-dimensions of engagement. Results suggest that self-efficacy was a strong predictor of engaged students. Additionally, high self-efficacious students were also less likely to be in disengagement groups than their peers.

Gender, Socio-economic Status, and Engagement

The social context also plays an important role in students' achievement-related behaviors including engagement. Although engagement is a demonstrative subject in the educational research area, only limited studies investigate the family background and student engagement (Reschly & Christenson, 2012). The results of the limited research that handles socio-economic status (SES) and engagement are mixed. For instance, in a recent study, Tomaszewski et al. (2020) investigated the effect of SES on students' engagement. According to the results, students from low-SES families tend to engage less than students from high-SES families. On the other hand, Bempechat and Shernoff (2012) suggest that not all low-SES students show disengagement, some low-SES students engage and achieve high levels, as well.

Gender differences in academic outcomes is also an important concern among researchers. Although many studies investigate girls' and boys' achievement differences, limited research handles gender differences in engagement (King, 2016). Moreover, research mostly suggests that girls are not only better performers than boys, but they also show higher engagement in academic domains. For instance, Kenney-Benson et al. (2006) investigated the underlined reasons for gender differences in academic outcomes. In total, 518 middle school students participated in the study. According to the results, girls tend to use positive learning strategies and show persistence more than boys. In another study, Şirin and Rogers-Şirin (2005) investigated how gender is related to students' engagement with 499 adolescents. According to the findings, girls tend to have higher engagement than boys. On the other hand, the findings of recent studies indicate that the gap between girls and boys is getting smaller. For instance, King (2016) investigated boys' and girls' motivation and engagement and suggested that girls and boys engage equally

in science. Supporting this idea, Bae and DeBusk-Lane (2019) investigated students' engagement profiles and suggest that gender is not a predictor of being in an engaged group or disengaged group.

Students' Engagement From a Cross-Cultural Perspective

Behavioral researchers emphasize that there may be cultural differences in an individual's behavior, attitude, or motivation in different countries (Tyler et al., 2008). One of the differences between countries may be their type of society. In collectivistic cultures, an individual's identity is defined according to the society, whereas in individualistic cultures, individuals are over the society. Hence, these differences may affect individuals' behaviors, emotions, or cognition (Markus et al., 1996). For instance, Chiu (2007) examined the relationship between students' family backgrounds and science outcomes across 41 countries. The findings of the study suggested that the effect of SES on students' outcomes in science is less strong in collectivistic cultures than individualistic cultures. Besides that, in individualistic societies, students tend to have more positive self-beliefs compared to collectivistic cultures (White & Lehman, 2005). However, they also tend to show lower performance compared to collectivistic cultures (Salili et al., 2001). On the other hand, since in collectivistic cultures students care about other people's opinions, the relation between their self-beliefs and performance is lower than their peers who live in an individualistic society (Chiu & Klassen, 2010).

Another factor that should be considered while investigating differences in countries is socio-economic development (Lam et al., 2016). For example, Kim et al. (2019) investigated the relation between SES and academic outcomes in developing countries with a meta-analysis. They include 49 studies in the study, and the data were from 38 countries. According to the results, there was a small, positive correlation between SES and academic outcomes. On the other hand, the strength of the relationship changes based on countries' economic development. To make it clearer, the relation between SES and outcomes was lower for low-income countries compared to middle-income countries. In other words, inequality of education is not stronger in developed countries. Since STEM career interest is related to students' science engagement and motivation (Wang & Degol, 2013), it can be helpful to discuss students' interest in STEM-related careers in high-SES and low-SES countries. Although STEM-related careers are considered as high-paid jobs with other benefits (Jacobson & Mokher, 2009), in many high-income countries, students' interest in STEM careers has been declining for a while (Joyce, 2014).

This Study

Expectancy–value theoretical model posits that students' social context, their expectancy beliefs about their success, and their perception of the value of the task are related to their achievement-related behavior, including engagement (Eccles et al.,

1983; Wigfield & Eccles, 1992). Although there is much engagement research in the relevant literature, a limited number of them handled it by considering SES variables (Reschly & Christenson, 2012). Besides that, according to the author's knowledge, it is unclear whether the EVT of engagement pattern is the same for different cultures or not. Therefore, this study aims to investigate how middle school students' contextual and motivational factors predict the likelihood of their science engagement in different countries. In other words, this study focuses on the possible generalizability of the effect of students' gender, SES, self-efficacy, and task value on their engagement in science. The research question of the study is as follows:

- How does the combination of gender, SES, and science motivation predict the likelihood of middle school students' science engagement in different countries?

Hence, this study aims to investigate the antecedents of middle school students' science engagement according to the EVT model from a cross-cultural perspective by using Trends in International Mathematics and Science Study (TIMSS) 2015 data. The proposed model is presented in Figure 2.

Method

Sample

The data of this study were gathered from the TIMSS. Since there was no evidence about engagement in TIMSS 2019, 2015 data were used. Trends in International

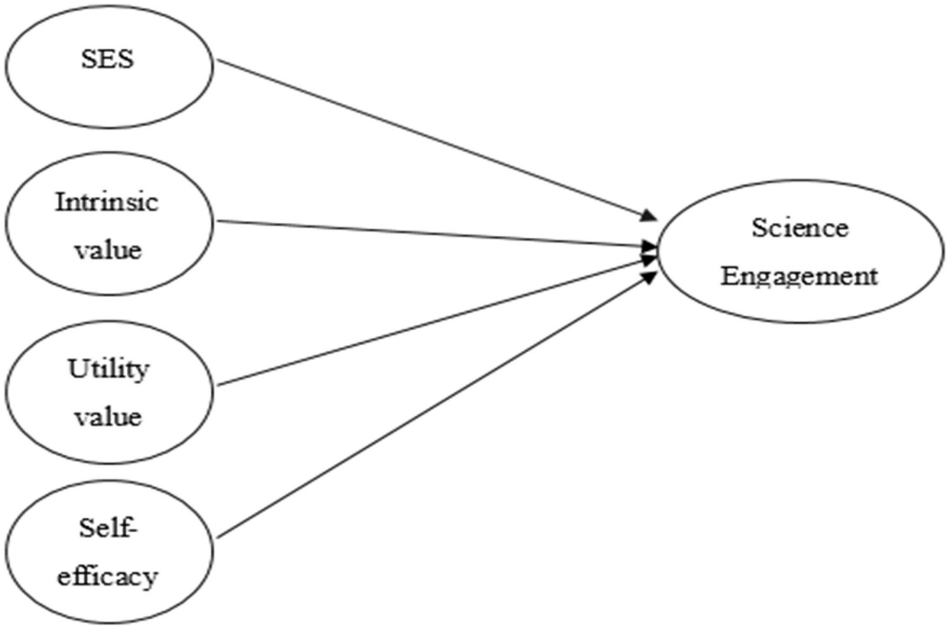

Figure 2.
Proposed Model of This Study.

Mathematics and Science Study is an international study that investigates fourth and eighth graders' science and math achievement and the background variables. In this study, eighth graders' data were used for secondary analysis. Besides that, there are 52 participant countries in TIMSS 2015. Moreover, each country conducts a sampling method to choose a nationally representative sample (LaRoche et al., 2016). Science is thought of separately as biology, chemistry, and physics in some countries; hence, this study did not involve these countries. The participant countries and their sample size were presented in Table 1.

Measures

Socio-economic Status

In this study, having own room or internet connection at home, parents, both mothers' and fathers' educational level, and the number of books variables were handled to evaluate students' SES because of their indicator role for predicting SES (Buchmann, 2002). About the educational level, there are five options: finished primary, lower secondary, upper secondary, post-secondary, and university or higher. In addition, the number of books item has five options: 0–10, 11–25, 26–100, 101–200, and more than 200. Trends in International Mathematics and Science Study created a continuous variable with these questions labeled as "home educational resources."

Science Engagement

It is a 4-point scale from "disagree a lot" to "agree a lot." There are 10 items to assess students' engagement in science. "My teacher listens to what I have to say," "I am interested in what my teacher says" are example items of the engagement scale. The reliability coefficient of Cronbach's alpha varies from .89 to .96 for countries and is presented in Table 1 for each country. Trends in International Mathematics and Science Study makes a categorization according to the total scores of students; very engaging, engaging, and less than engaging. Since this study aims to investigate the very engaging students, they are coded as 1, and others are coded as 0. Therefore, a dummy variable was created.

Self-Efficacy

It is a 4-point scale from "disagree a lot" to "agree a lot." There are nine items to assess students' self-efficacy in science. Although in TIMSS this subscale is named as self-confidence, Evans (2015) suggests that they assess students' self-efficacy beliefs. "Science is not one of my strengths" and "I learn things quickly in science" are example items of the self-efficacy scale. The reliability coefficient of Cronbach's alpha varies from .72 to .93 for countries and is presented in Table 1 for each country.

Task Value

Task value has four components: utility value, intrinsic value, attainment value, and cost (Wigfield & Eccles, 2000). However, since TIMSS assesses only intrinsic and utility value, this study will handle these two components of task value. Trends

Table 1.
Means, Standard Deviations, and Reliability Coefficients of Engagement and Motivational Beliefs

		Engagement[a]			Self-Efficacy[b]			Intrinsic Value[c]			Utility Value[d]		
	N	Mean	SD	Reliability	Mean	SD	Reliability	Mean	SD	Reliability	Mean	SD	Reliability
Australia	10,338	9.66	2.04	.95	9.77	2.12	.90	9.66	2.12	.66	9.56	2.00	.94
Bahrain	4918	10.31	2.07	.94	10.59	2.10	.76	10.40	2.18	.76	10.64	2.09	.93
Botswana	5964	10.36	1.85	.89	9.81	1.83	.74	11.03	1.89	.51	11.50	1.64	1.86
Canada	8757	9.92	1.97	.95	10.23	2.12	.90	9.90	2.00	.63	10.07	1.87	.92
Chile	4849	10.14	2.07	.95	9.83	1.97	.82	9.72	1.97	.70	9.67	2.06	.93
Chinese Taipei	5711	8.98	1.73	.93	8.65	2.37	.93	9.18	1.91	.67	8.59	1.71	.92
Egypt	7822	10.91	1.83	.89	10.58	2.05	.70	10.84	1.96	.67	11.24	1.84	.90
England	4814	9.67	1.87	.94	9.96	2.21	.90	9.78	2.11	.61	10.12	1.87	.93
Hong Kong	4155	9.65	1.99	.96	9.44	2.05	.88	9.87	2.02	.72	9.43	1.91	.94
Hungary	6130	10.53	1.90	.92	10.67	2.20	.83	10.67	2.04	.64	9.29	1.67	.91
Iran	4704	9.85	2.04	.94	10.06	2.46	.91	9.81	2.18	.65	10.82	1.89	.92
Ireland	5512	9.82	2.34	.95	10.54	2.51	.86	9.54	2.29	.71	9.59	1.95	.94
Israel	4481	9.61	1.72	.92	10.35	1.98	.88	9.77	1.88	.55	10.00	2.26	.90
Italy	4745	8.42	1.52	.93	8.57	1.90	.89	9.00	1.78	.70	9.00	1.64	.90
Japan	7865	11.07	1.89	.93	10.68	2.05	.72	11.03	2.09	.73	8.64	1.52	.92
Jordan	5309	8.35	1.60	.94	8.64	2.08	.93	8.58	1.75	.67	11.37	1.90	.92
Korea	4503	10.49	1.84	.91	10.76	2.08	.78	10.57	2.12	.67	8.94	1.66	.90
Kuwait	9726	10.38	1.67	.93	8.54	1.99	.72	11.05	1.81	.66	10.60	1.88	.89
Malaysia	8142	9.82	1.93	.90	9.67	1.98	.75	9.84	2.05	.67	10.46	1.57	.93
New Zealand	4697	9.56	1.86	.95	10.47	2.15	.88	9.72	1.96	.65	9.76	1.91	.92
Norway	8883	10.67	1.70	.94	10.73	1.96	.90	10.83	1.93	.57	9.39	1.70	.89
Oman	5403	10.09	2.20	.95	10.45	2.07	.79	10.21	2.18	.78	11.06	1.72	.94
Qatar	3759	10.35	2.04	.93	10.51	2.03	.72	10.31	2.25	.78	10.56	2.15	.93
Saudi Arabia	6116	9.78	1.71	.94	9.65	2.14	.91	10.28	2.01	.56	10.48	2.13	.90
South Africa	12,514	10.60	1.75	.89	10.20	1.95	.77	10.64	1.93	.64	10.85	1.90	.91
Thailand	6482	10.13	1.61	.92	9.32	1.42	.75	10.30	1.70	.66	10.77	1.66	.91

Turkey	6079	10.71	1.84	.91	10.65	2.25	.84	10.74	1.95	.59	10.41	1.92	.90
United Arab Emirates	18,012	10.03	2.03	.95	10.41	1.98	.81	10.28	2.11	.72	10.43	2.02	.93
United States	10,221	10.18	2.19	.96	10.51	2.27	.88	10.02	2.16	.69	10.06	2.00	.92

Note: [a]The lower limits are 8.1 for moderate level and 10.2 for high level.
[b]The lower limits are 9.2 for moderate level and 11.5 for high level.
[c]The lower limits are 8.3 for moderate level and 10.7 for high level.
[d]The lower limits are 8.4 for moderate level and 10.7 for high level.
SD = standard deviation.

in International Mathematics and Science Study assessed utility value with eight items in 2015 with a 4-point scale from "disagree a lot" to "agree a lot." "I think learning science will help me in my daily life" and "Learning science will give me more job opportunities when I am an adult" are examples of the subscale. The reliability coefficient of Cronbach's alpha varies from .76 to .94 for countries and is presented in Table 1 for each country. Besides that, TIMSS assessed intrinsic value with nine items in 2015 with a 4-point scale from "disagree a lot" to "agree a lot." "I enjoy learning science" and "I like science" are examples of the subscale. The reliability coefficient of Cronbach's alpha varies from .51 to .76 for countries and is presented in Table 1 for each country.

Results

Trends in International Mathematics and Science Study 2015 data were gathered from (https://timssandpirls.bc.edu/timss2015/internationaldatabase) the website of TIMSS. In this study, the data were created and analyzed via International Database analyzer version 4.0. International Database analyzer was developed by the International Association for the Evaluation of Educational Achievement (IEA) and can handle large survey data and consider sampling weights (IEA, 2013).

Descriptive Statistics

To investigate eighth graders' profiles regarding engagement and motivational beliefs in science, descriptive statistics were used. According to the descriptive results, most of the countries' students both

tend to show engagement in science at a moderate level and have a moderate level of motivation to learn science. Among countries participating in this study, Japanese students show the highest engagement (M=11.07, SD=1.89), Korean students have the highest self-efficacy level (M=10.76, SD=2.08), and Botswana students have the strongest value beliefs (intrinsic value (M=11.03, SD=1.89) and utility value (M=11.50, SD=1.86)). On the other hand, Jordon students show the lowest engagement (M=8.35, SD=1.60) and have the lowest intrinsic value (M=8.58, SD=1.75), Kuwaiti students have the lowest self-efficacy level (M=8.54, SD=1.99), and Chinese Taipei students have the strongest value beliefs (M=8.59, SD=1.71). Means and standard deviations of engagement and motivational beliefs were presented in Table 1 for each country.

Inferential Statistics

A binary logistic regression was conducted to determine the effect of students' background variables (gender and SES), science motivational beliefs on the students' science engagement. The model includes two dummy variables. gender and science engagement. Girls and engaged students were coded as 1. While considering categorical predictors, the first categories (coded as 0) were handled as indicator variables. Before performing the analysis, preliminary analyses were conducted to check the assumptions of the binary logistic. None of the assumptions of the analysis were violated. The correlations among the independent continuous variables were not only significant for all the participant countries but also under .8, which is the critical value for multicollinearity. Since the independent variables have a different number of items, all the variables are transformed to z-scores before conducting analyses. After the transformation, none of the correlations were changed. Hence, the binary logistic analysis was performed. The explained variance (*Nagelkerke R*2) for the average of the participant countries was .44. To reduce Type I error, the Bonferonni defined alpha level, .01 (.05/5), was used while investigating independent variables' impact (Pallant, 2001). Moreover, to investigate variables' effect size, odds ratio values were converted to Cohen's *d* (Chinn, 2000). The lower limits are .20 for small effect, .50 for moderate effect, and .80 for large effect (Cohen, 1988).

According to the model, in most of the participant countries, there was no significant difference between girls and boys in terms of engaging in science. On the other hand, in Malaysia, Oman, Saudi Arabia, and Turkey, girls tend to engage significantly higher than boys with small effect (d < .50). Regarding SES, while in some countries SES statistically contributes to the model, the effect size was very small to be considered (d < .20). Hence, findings suggest that SES had no practically significant impact on students' engagement in all countries. Last but not least, motivational variables' role showed variety across countries. While all the motivational variables statistically contributed to the model, self-efficacy and task value had lost their practical

significance for some countries. In conclusion, three different groups occurred in terms of motivational effect. In Botswana, Italy, Norway, Kuwait, South Africa, and the United States, all the motivational beliefs significantly and positively affect students' engagement. In the second group of countries (Chile, Chinese Taipei, Egypt, Hong Kong, Iran, Israel, Japan, Jordan, Korea, Malaysia, Oman, Qatar, Singapore, Thailand, and Turkey), self-efficacy was not significant. Additionally, in Canada, England, Ireland, New Zealand, and the United Arab Emirates, the only intrinsic value was significant. Beta values, odds ratios, and Cohen's *d* for the models for each country are presented in Table 2.

Discussion, Conclusion, and Recommendations

This study aimed to investigate the antecedents of middle school students' science engagement from a cross-cultural perspective. Gender, SES, and students' motivational beliefs were handled as predictors of engagement. The data are gathered from TIMSS 2015.

Motivational Beliefs and Engagement

The relevant literature underlines the importance of students' motivational beliefs for their achievement-related behaviors including engagement (Eccles & Wang, 2012). In this study, students' self-efficacy and task value beliefs were investigated as to their motivational beliefs. The findings of this study suggest three different situations for the relation between motivation and engagement. In the first group of countries (Botswana, Italy, Norway, Kuwait, South Africa, and the United States), all the motivational beliefs significantly and positively affect students' engagement. In other words, in these countries, students who think that they can achieve the task in science, find science useful, and enjoyable tend to engage in science more than their peers. This result is consistent with the EVT and previous studies. For instance, Linnenbrink-Garcia et al. (2018) investigated students' motivation and engagement relation. They made a classification by considering students' motivation levels. According to the results, the high confident-value group, having a high level of self-efficacy and task value, was the group that shows the highest engagement. In another study, Bae and DeBusk-Lane (2019) investigated middle school students' engagement profiles and suggest that self-efficacy is a predictor of engaged students. Furthermore, EVT also highlights the importance of individuals' two motivational beliefs for their achievement-related behavior like engagement (Wigfield & Eccles, 1994).

In the second group of countries (Chile, Chinese Taipei, Egypt, Hong Kong, Iran, Israel, Japan, Jordan, Korea, Malaysia, Oman, Qatar, Singapore, Thailand, and Turkey), self-efficacy failed its statistical or practical significance. In other words, only students' task value beliefs, both utility and intrinsic value, positively affect their engagement in science. The task value's positive attribution was an expected result since according

Table 2.
Logistic Regression Results for Each Country

		Gender			SES			Self-Efficacy			Intrinsic Value			Utility Value		
Countries	R^2	***B* (SE)**	**Odds Ratio**	**Cohen's *d***	***B* (SE)**	**Odds Ratio**	**Cohen's *d***	***B* (SE)**	**Odds Ratio**	**Cohen's *d***	***B* (SE)**	**Odds Ratio**	**Cohen's *d***	***B* (SE)**	**Odds Ratio**	**Cohen's *d***
Australia	.44	−.06 (.09)	1.06	.03	−.18 (.09)	1.00	.00	.13 (.03)*	1.32	.15	.65 (.03)*	3.92	.76[b]	.12 (.02)*	1.27	.13
Bahrain	.47	−.14 (.09)	1.14	.07	−.21 (.16)	.89	.07	.11 (.03)*	1.30	.14	.52 (.03)*	2.96	.60[b]	.32 (.03)*	1.90	.35[a]
Botswana	.43	.07 (.09)	.92	.05	−.56 (.26)*	.91	.05	.16 (.03)*	1.43	.20[a]	.47 (.03)*	2.67	.54[b]	.45 (.03)*	2.48	.50[b]
Canada	.35	−.12 (.07)	1.13	.07	−.26 (.01)*	.92	.05	.15 (.03)*	1.38	.18	.51 (.03)*	2.93	.59[b]	.12 (.02)*	1.26	.13
Chile	.43	−.09 (.10)	1.09	.05	−.65 (.23)*	.89	.06	.12 (.04)*	1.30	.15	.68 (.04)*	4.18	.79[b]	.22 (.03)*	1.55	.24[a]
Chinese Taipei	.38	−.29 (.08)*	1.28	.14	−.25 (.12)	.89	.06	.02 (.03)	1.05	.03	.64 (.04)*	3.86	.75[b]	.24 (.04)*	1.62	.27[a]
Egypt	.51	−.29 (.11)*	1.34	.16	−.15 (.16)	.99	.00	.15 (.03)*	1.37	.17	.40 (.04)*	2.30	.46[b]	.67 (.03)*	3.84	.74[a]
England	.40	−.01 (.09)	1.02	.01	−.57 (.14)*	.75	.16	.14 (.03)*	1.37	.17	.56 (.04)*	3.27	.65[b]	.11 (.03)*	1.25	.12
Hong Kong	.43	−.19 (.08)*	1.21	.10	−.15 (.07)	.94	.03	.08 (.04)*	1.19	.10	.62 (.04)*	3.64	.71[b]	.25 (.04)*	1.66	.28[a]
Iran	.50	−.33 (.10)*	1.37	.17	−.42 (.15)*	.87	.07	.15 (.03)*	1.42	.19	.60 (.03)*	3.48	.69[b]	.37 (.03)*	2.10	.41[a]
Ireland	.42	.03 (.08)	.98	.01	−.52 (.10)*	.83	.11	.10 (.03)*	1.23	.12	.61 (.04)*	3.61	.71[b]	.09 (.03)*	1.20	.10
Israel	.52	−.11 (.10)	1.13	.07	−.57 (.12)*	.72	.18	.11 (.02)*	1.31	.15	.70 (.04)*	4.28	.80[c]	.22 (.03)*	1.56	.25[a]
Italy	.34	−.20 (.10)*	1.23	.12	−.25 (.15)	.83	.10	.16 (.03)*	1.46	.21[a]	.46 (.05)*	2.62	.53[b]	.22 (.04)*	1.57	.25[a]
Japan	.38	.01 (.14)	.99	.00	.33 (.12)*	1.14	.07	−.14 (.04)*	.75	.16	.79 (.05)*	5.27	.92[c]	.27 (.04)*	1.70	.29[a]
Jordan	.48	−.18 (.12)	1.20	.10	−.28 (.28)	.99	.00	.11 (.04)*	1.27	.13	.54 (.03)*	3.10	.63[b]	.47 (.02)*	2.53	.51[b]
Korea	.46	−.17 (.14)	1.19	.10	.17 (.14)	1.09	.05	.11 (.04)*	1.26	.13	.72 (.05)*	4.47	.83[c]	.31 (.05)*	1.87	.34[a]
Kuwait	.39	−.21 (.18)	1.24	.12	.10 (.22)	.94	.03	.18 (.03)*	1.50	.23[a]	.36 (.04)*	2.12	.41[b]	.38 (.03)*	2.12	.41[a]
Malaysia	.48	−.43 (.09)*	1.53	.24[a]	.13 (.18)	.95	.03	.06 (.02)*	1.13	.07	.92 (.03)*	6.84	1.06[c]	.19 (.03)*	1.46	.21[a]
New Zealand	.44	−.15 (.09)	1.17	.08	−.20 (.09)*	.93	.04	.08 (.03)*	1.19	.10	.73 (.03)*	4.62	.85[c]	.01 (.02)*	1.26	.13
Norway	.41	.05 (.09)	.96	.02	−.27 (.10)*	.84	.10	.22 (.04)*	1.65	.28[a]	.51 (.04)*	2.91	.59[b]	.20 (.04)*	1.48	.22
Oman	.51	−.38 (.09)*	1.47	.21[a]	−.10 (.14)	1.02	.01	.12 (.03)*	1.29	.14	.57 (.03)*	3.32	.66[b]	.57 (.03)*	3.14	.63[b]
Qatar	.51	−.13 (.12)	1.14	.07	−.18 (.14)	.87	.08	.11 (.04)*	1.28	.14	.54 (.04)*	3.09	.62[b]	.39 (.03)*	2.19	.43[a]
Saudi Arabia	.53	−.50 (.12)*	1.65	.28[a]	−.46 (.23)	.92	.05	.22 (.07)*	1.62	.27[a]	.39 (05)*	2.27	.45[b]	.53 (.07)*	2.88	.58[b]
Singapore	.43	.00 (.07)	1.01	.00	.02 (.11)	.90	.06	.10 (.03)*	1.25	.13	.54 (.03)*	3.13	.63[b]	.30 (.03)*	1.85	.34

South Africa	.38	−.16 (.06)*	1.17	.08	−.26 (.20)	.91	.06	.19 (.02)*	1.53	.23[a]	.42 (.03)*	2.41	.49[b]	.27 (.02)*	1.73	.30[a]
Thailand	.50	−.08 (.07)	1.08	.04	−.82 (.17)*	.75	.16	.03 (.05)	1.10	.05	.79 (.05)*	5.16	.91[c]	.50 (.03)	2.80	.57[b]
Turkey	.42	−.41 (.09)*	1.51	.23[a]	−.36 (.16)*	.93	.04	.11 (.03)*	1.28	.13	.57 (.03)*	3.27	.65[b]	.31 (.03)*	1.84	.34[a]
United Arab Emirates	.46	−.03 (.07)	1.07	.04	−.04 (.09)	.91	.05	.07 (.02)*	1.08	.04	.57 (.03)*	3.05	.62[b]	.31 (.02)*	1.35	.17
United States	.42	−.20 (.06)*	1.22	.11	−.22 (.08)*	.88	.07	.17 (.02)*	1.44	.20[a]	.52 (.03)*	2.99	.60[b]	.18 (.02)*	1.44	.20[a]

Note: *Statistically significant.
[a]Effect size is small.
[b]Effect size is moderate.
[c]Effect size is large.
SE = standard error.

to the EVT of engagement, task value and expectancy of success are main predictors of achievement outcomes like engagement (Eccles & Wang, 2012). Besides that, previous research found similar findings and confirmed the model; high task value beliefs lead students to participate in the activities, make effort, use different strategies namely increase their engagement (Linnenbrink & Pintrich, 2003). On the other hand, the insignificant effect of self-efficacy was not an unexpected outcome since the relevant literature also suggests the positive relationship between self-efficacy and engagement (Hoy, 2004; Linnenbrink & Pintrich, 2003). Moreover, the EVT emphasizes the role of students' beliefs about their performance at the task and suggests that it is one of the main predictors of students' achievement-related behaviors including engagement (Eccles & Wang, 2012). The reason for this surprising result can be a cultural effect. Namely, these countries show collectivistic cultural characteristics (Hofstede Insights, 2021). In collectivistic societies, although students may have higher self-beliefs, the effect of these beliefs on their academic outcomes may be lower (Chiu & Klassen, 2010).

In the third group of countries (Canada, England, Ireland, New Zealand, and the United Arab Emirates), the intrinsic value was solely the precursor of science engagement for middle school students. It was another unexpected result of this study. The common characteristic of these countries is that all of them are high-income countries (World Bank, 2021). Having less future anxiety may provide students the opportunity

to engage in tasks that only they enjoy. Supporting this idea, in developing countries, STEM-related jobs are seen as more well paid than other jobs (Bahar & Adiguzel, 2016; Joyce, 2014). Hence, this can make individuals, both students, and their parents, desire a STEM career and find science and mathematics useful for them. Consequently, their utility value beliefs can be much influential on engagement more than their peers from high-SES countries. Since the countries in the third group are high-SES countries, only liking and enjoying the task may have a significant effect on students' engagement. The other reason for this unexpected result can be the multidimensional structure of engagement. Namely, only one dimension of engagement, behavioral engagement, was handled in this study. In high-income countries, students' utility value and self-efficacy beliefs may be significant for other dimensions of engagement. It is worth investigating it in a further study in detail.

Gender, Socio-economic Status, and Engagement

The findings of this study showed that in many participant countries, there was no significant effect of gender on science engagement. In the rest of the participant countries, the effect size of gender was very small to be considered except Malaysia, Oman, Saudi Arabia, and Turkey. In the listed exceptional countries, girls engage in science more than boys with a small effect size. In other words, it can be summarized as that boys and girls engage in science similarly. Despite the limited number of researches in the literature about gender differences in engagement (King, 2016), this finding is not a surprising result. Educational researchers pay attention to gender differences in achievement-related outcomes and underline that girls are better than boys (Voyer & Voyer, 2014) or generally equal to boys (King, 2016) at many academic outcomes. Parallel to the relevant literature, the findings of this study show that there were no gender differences in science engagement practically in all participant countries except for Malaysia, Oman, Saudi Arabia, and Turkey.

Regarding SES, there was no practically significant effect of SES on engagement for all countries. Previous studies related to the relation between SES and engagement are also mixed; some of them support that high-SES students engage more than low-SES students (Tomaszewski et al., 2020), others discuss that some low-SES students show high engagement (Bempechat & Shernoff, 2012). Besides, Kim et al. (2019) suggested that the correlation between SES and achievement outcomes can show variety for different countries. Additionally, the gap between students from high-income families and low-income families is stronger for economically developing countries. However, in this study, the relation between SES and engagement was not significant for even low-SES countries. Science, technology, engineering, and mathematics-related careers opportunities like earning high money in the eyes of people can help to understand this surprising result (Jacobson & Mokher, 2009). Children from low-SES families can think of STEM careers as a way to access the

opportunities; therefore, they can be interested and engage in science. Besides that, there are limited studies that investigate these kinds of family background variables' impact on students' engagement (Reschly & Christenson, 2012), so in a further study, it can be investigated by considering the other dimensions of engagement.

This study aimed to investigate the relationship between gender, SES, motivational beliefs, and science engagement from a cross-cultural perspective. There was no correlation between gender and engagement for all countries with four expectations. In Malaysia, Oman, Saudi Arabia, and Turkey, girls tend to engage in science more than boys but with a small effect size. Moreover, there was no practical relation between SES and engagement. Regarding motivational variables, the findings suggested that the relationship changes for different countries. To explain this variation, countries' cultural and economical differences were considered in this study. Among all predictor variables, students' intrinsic value beliefs were solely common precursors of science engagement for all the participant countries.

This study has some limitations. First, it is a cross-sectional study and does not imply a cause–effect relationship. At this point, it is important to underline that the term "effect" was used as a statistical effect not a causal effect in this study. Besides that, since TIMSS data include only intrinsic and utility value data, the four components of task value couldn't be included in the study. A similar limitation is also valid for engagement. The multidimensional construct of engagement could not be considered in the current study. In a further study, the EVT of the engagement model can be tested for all dimensions of engagement.

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References

Bae, C. L., & DeBusk-Lane, M. (2019). Middle school engagement profiles: Implications for motivation and achievement in science. *Learning and Individual Differences*, *74*, 101–753. [CrossRef]

Bahar, A., & Adiguzel, T. (2016). Analysis of factors influencing interest in STEM career: Comparison between American and Turkish high school students with high ability. *Journal of STEM Education: Innovations and Research*, *17*(3), 64–69. Retrieved from http://ezproxy.libproxy.db.erau.edu/login?url=https://search.proquest.com/docview/1833037480?accountid=27203.

Bandura, A. (1977). *Social learning theory*. New York: General Learning Press.

Bempechat, J., & Shernoff, D. J. (2012). Parental influences on achievement motivation and student engagement. In *Handbook of research on student engagement* (pp. 315–342). Berlin: Springer. [CrossRef]

Buchmann, C. (2002). Measuring family background in international studies of education: Conceptual issues and methodological challenges. *Methodological Advances in Cross-National Surveys of Educational Achievement*, 150–197.

Chinn, S. (2000). A simple method for converting an odds ratio to effect size for use in meta-analysis. *Statistics in Medicine*, *19*(22), 3127–3131. [CrossRef]

Chiu, M. M. (2007). Families, economies, cultures, and science achievement in 41 countries: Country-, school-, and student-level analyses. *Journal of Family Psychology*, *21*(3), 510–519. [CrossRef]

Chiu, M. M., & Klassen, R. M. (2010). Relations of mathematics self-concept and its calibration with mathematics achievement: Cultural differences among fifteen-year-olds in 34 countries. *Learning and Instruction*, *20*(1), 2–17.

Christenson, S. L., Reschly, A. L., & Wylie, C. (Eds.). (2012). *Handbook of research on student engagement*. *Springer Science & Business Media*.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed). Hillsdale, NJ: Erlbaum.

Cole, J. S., Bergin, D. A., & Whittaker, T. A. (2008). Predicting student achievement for low stakes tests with effort and task value. *Contemporary Educational Psychology*, *33*(4), 609–624. [CrossRef]

Eccles, J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J., & Midgley, C. (1983). Expectancies, values and academic behaviors. In Spence, J. T. (Ed.), *Achievement and achievement motives*. San Francisco: W. H. Freeman.

Eccles, J., & Wang, M. T. (2012). Part I commentary: So what is student engagement anyway?. In *Handbook of research on student engagement* (pp. 133–145). Berlin: Springer.

Evans, J. A. (2015). Gender, self-efficacy, and mathematics achievement: An analysis of fourth grade and eighth grade TIMSS data from the United States. *Educational Studies Dissertations*, 63.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59–109. [CrossRef]

Hofstede Insights. (2021). Country comparison. *Hofstede Insights*. Retrieved from https://www.hofstede-insights.com/country-comparison/.

Hoy, A. W. (2004). Self-efficacy in college teaching. *Essays on Teaching Excellence: Toward the Best in the Academy*, *15*(7), 8–11.

International Association for the Evaluation of Educational Achievement (IEA). (2013). *IDB Analyzer (Computer software and manual)*. Hamburg, Germany: IEA.

Jacobson, L., & Mokher, C. (2009). *Pathways to boosting the earnings of low-income students by increasing their educational attainment*. Hudson Institute (NJ1).

Joyce, A. (2014). *Stimulating interest in STEM careers among students in Europe: Supporting career choice and giving a more realistic view of STEM at work*. European Schoolnet, Brussels.

Kenney-Benson, G. A., Pomerantz, E. M., Ryan, A. M., & Patrick, H. (2006). Sex differences in math performance: The role of children's approach to schoolwork. *Developmental Psychology*, *42*(1), 11–26. [CrossRef]

Kim, Sw, Cho, H., & Kim, L. Y. (2019) Socioeconomic status and academic outcomes in developing countries: A meta-analysis. *Review of Educational Research*, *89*(6), 875–916. [CrossRef]

King, R. B. (2016). Gender differences in motivation, engagement and achievement are related to students' perceptions of peer but not of parent or teacher attitudes toward school. *Learning and Individual Differences*, *52*, 60–71. [CrossRef]

Lam, S. F., Jimerson, S., Shin, H., Cefai, C., Veiga, F. H., Hatzichristou, C., Polychroni, F., Kikas, E., Wong, B. P. H., Stanculescu, E., Basnett, J., Duck, R., Farrell, P., Liu, Y., Negovan, V., Nelson, B., Yang, H., & Zollneritsch, J. (2016). Cultural universality and specificity of student engagement in school: The results of an international study from 12 countries. *British Journal of Educational Psychology*, *86*(1) , 137–153. [CrossRef]

LaRoche, S., Joncas, M., & Foy, P. (2016). Sample design in TIMSS 2015. *Methods and Procedures in TIMSS*, *2015*, 0–37. Retrieved from https://timssandpirls.bc.edu/publications/timss/2015-methods/chapter-3.html

Linnenbrink, E. A., & Pintrich, P. R. (2003). The role of self-efficacy beliefs in student engagement and learning in the classroom. *Reading and Writing Quarterly*, *19*(2), 119–137. [CrossRef]

Linnenbrink-Garcia, L., Wormington, S. V., Snyder, K. E., Riggsbee, J., Perez, T., Ben-Eliyahu, A., & Hill, N. E. (2018). Multiple pathways to success: An examination of integrative motivational profiles among upper elementary and college students. *Journal of Educational Psychology*, *110*(7), 1026–1048. [CrossRef]

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education*, *32*(5), 669–685. [CrossRef]

Markus, H., Kitayama, S., & Heiman, R. (1996). Culture and "basic" psychological principles. In E. Tory Higgins & A. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 857–913). New York: Guilford Press.

Pallant, J. (2010). *SPSS survaival manual: a step by step guide to data analysis using SPSS*. NY, USA.

Pugh, K. J., Linnenbrink-Garcia, L., Koskey, K. L. K., Stewart, V. C., & Manzey, C. (2010). Motivation, learning, and transformative experience: A study of deep engagement in science. *Science Education*, *94*(1), 1–28. [CrossRef]

Reschly, A. L., & Christenson, S. L. (2012). Jingle, jangle, and conceptual haziness: Evolution and future directions of the engagement construct. In S. L. Christenson, A. L. Reschly & C. Wylie (Eds.), *Handbook of research on student engagement* (pp.3–19). Berlin: Springer.

Ryu, S., & Lombardi, D. (2015). Coding classroom interactions for collective and individual engagement. *Educational Psychologist*, *50*(1), 70–83. [CrossRef]

Salili, F., Chiu, C. Y., & Lai, S. (2001). The influence of culture and context on students' motivational orientation and performance. In F. Salili, C. Y. Chie& Y. Y. Hong (Eds.), *Student motivation* (pp. 221–247). Dordrecht: Kluwer Publishers.

Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2010). *Motivation in education: Theory, research and application*. Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

Sirin, S. R., & Rogers-Sirin, L. (2005). Components of school engagement among African American adolescents. *Applied Developmental Science*, *9*(1), 5–13.

Skinner, E. A., & Pitzer, J. R. (2012). Developmental dynamics of student engagement, coping, and everyday resilience. In *Handbook of research on student engagement* (pp. 21–44). Berlin: Springer.

Tomaszewski, W., Xiang, N., & Western, M. (2020). Student engagement as a mediator of the effects of socio-economic status on academic performance among secondary school students in Australia. *British Educational Research Journal*, *46*(3), 610–630. [CrossRef]

Tyler, K. M., Uqdah, A. L., Dillihunt, M. L., Beatty-Hazelbaker, R., Conner, T., Gadson, N., Henchy, A., Hughes, T., Mulder, S., Owens, E., Roan-Belle, C., Smith, L., & Stevens, R. (2008). Cultural discontinuity: Toward a quantitative investi- gation of a major hypothesis in education. *Educational Researcher*, *37*(5), 280–297. [CrossRef]

Voyer, D., & Voyer, S. D. (2014). Gender differences in scholastic achievement: A metaanalysis. *Psychological Bulletin*, *140*(4), 1174–1204. [CrossRef]

Wang, M. T., & Degol, J. (2013). Motivational pathways to STEM career choices: Using expectancy–value perspective to understand individual and gender differences in STEM fields. *Developmental Review*, *33*(4), 304–340. [CrossRef]

White, K., & Lehman, D. R. (2005). Culture and social comparison seeking: The role of self-motives. *Personality and Social Psychology Bulletin*, *31*(2), 232–242. [CrossRef]

Wigfield, A., & Eccles, J. S. (1992). The development of achievement task values: A theoretical analysis. *Developmental Review*, *12*(3), 265–310. [CrossRef]

Wigfield, A., & Eccles, J. S. (1994). Expectancy-value theory of achievement motivation: A developmental perspective. *Educational Psychology Review*, *6*(1), 49–78. [CrossRef]

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68–81. [CrossRef]

World Bank. (2021). New World Bank country classifications by income level: (2021–2022). Retrieved from https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2021-2022.