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Latent profile analysis of students' science motivation and cognitive dimensions relationships

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ABSTRACT The aim of this study was to identify students' motivational beliefs in science and revealed the connections between the profiles and three cognitive dimensions of science achievement through the examination of the socio-economic status (SES) and gender covariates of the profile memberships. Latent profile analysis using science motivational beliefs was conducted, and resulted in a four-profile model. The emerging profiles were named "low motivation", "moderate motivation", "high motivation", and "high motivation with very high confident". The results showed that the boys were less likely to have "high motivation" and "high motivation with very high confidence" profiles than the girls. The students with high SES were more likely to belong to the high motivation groups. The differences between the mean scores of the students in different motivation profiles were statistically significant in all other pairwise comparisons, except for the comparisons between the low and moderate motivation profiles. Our findings suggest that students' motivation toward science should take an integrative approach to improve students' cognitive dimensions of science achievement by considering students' gender and SES.

Keywords: *Cognitive domains, Latent profile analysis, Science's achievement, Science's motivational beliefs, TIMSS*

Öğrencilerin fen motivasyonu ve bilişsel boyutları arasındaki ilişkilerin örtük profil analiziyle incelenmesi

ÖZ Bu çalışmanın amacı, öğrencilerin fen alanındaki motivasyonel inançlarını belirlemek ve profil üyeliklerinin sosyo-ekonomik duzey (SES) ve cinsiyet ortak değişkenlerinin incelenmesiyle ortaya konan profiller ile fen başarısının üç bilişsel alanı arasındaki iliskiyi ortaya çıkarmaktır. Bu çalışmada, fen motivasyonel inançları kullanılarak örtük profil analizi yapılmış ve dört profilli bir model ortaya çıkmıştır. Ortaya çıkan profiller "düşük motivasyon", "orta motivasyon", "yüksek motivasyon" ve "çok yüksek özgüvenli yüksek motivasyon" olarak adlandırılmıştır. Sonuçlar, erkek öğrencilerin kız öğrencilere kıyasla "yüksek motivasyon" ve "yüksek motivasyon ve çok yüksek özgüven" profillerine daha az sahip olduğunu göstermiştir. Yüksek SES'e sahip öğrencilerin yüksek motivasyon gruplarına ait olma olasılığının daha yüksek olduğu elde edilmiştir. Farklı motivasyon profillerinde yer alan öğrencilerin ortalama puanları arasındaki farklar, düşük ve orta motivasyon profilleri arasındaki karşılaştırmalar hariç, diğer tüm ikili karşılaştırmalarda istatistiksel olarak anlamlı çıkmıştır. Bulgularımız, öğrencilerin fene yönelik motivasyonlarının, öğrencilerin cinsiyet ve SES'lerini dikkate alarak fen başarısının bilişsel boyutlarını geliştirmek için bütüncül bir yaklaşım benimsenmesi gerektiğini göstermektedir.

Anahtar Sözcükler: *Bilişsel alanlar, Fen başarısı, Fen motivasyonel inançları, Örtük profil analizi, TIMSS*

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INTRODUCTION

Science education is an important discipline that plays a role in training individuals for a knowledge-based economy (Moakler & Kim, 2014). Promoting science achievement is an essential goal for educators and policymakers (Curran & Kellogg, 2016). Hence, educational researchers have focused on malleable factors such as motivational beliefs influencing science academic achievement (Fong et al., 2021).

Situated Expectancy Value Theory (SEVT) is one of the effective educational psychology theories that is widely used to explain learners' motivation toward learning and academic achievement (Wigfield & Eccles, 2000). SEVT assumes that individuals' expectation of success (expectancy beliefs) and their personal beliefs about the value of academic tasks (value beliefs) are the primary and proximal predictors of academic achievement (Eccles & Wigfield, 2020; Gaspard et al., 2019; Lee et al., 2022; Wigfield & Eccles, 2000). Empirical research confirms the assumption that science motivational beliefs are related to science achievement including expectancy and value beliefs (Berger et al., 2020; Liou & Liu, 2015; Perez et al., 2019).

In SEVT, there is also a relationship between cultural differences and characteristics, such as gender and SES, and science motivational beliefs (e.g. Eccles & Wigfield, 2020; Hu et al., 2018; Wan, 2021; Wan & Lee, 2017). In these studies, the researchers mostly studied SEVT from a cross-cultural perspective. However, Tonks et al. (2018) highlighted that there was a gap that needs to be investigated the relationship between expectancy and value beliefs, and achievement in various cultures. Tonks et al. (2018) discussed how cultural aspects (i.e., individualism, and collectivism) could affect the SEVT model. Opportunities offered to children and whether children's decision-making situations are supported may differ according to culture or belong to certain groups (e.g., gender, SES, ethnicity) within a culture (Tonks et al., 2018). For instance, while children are encouraged to make their own activity choices in an individualistic culture (Jacobs & Eccles, 2000) in China, which has a collectivist society, individuals decide on their career choices in line with the needs of the society rather than their skills (Tonks et al., 2018). In a cultural context where it is explicitly or implicitly implied that girls are talented in reading and boys in math, gender stereotypes can affect academic motivation and academic achievement (Spencer et al., 1999). Students who are supported by their families with learning materials or extracurricular learning activities and given information about science may have higher motivational beliefs than other students (Gorard & See, 2009; Liu & Schunn, 2020). Briefly, previous experiences, surrounding cultural elements, norms, gender, gender stereotypes, and socio-economic and cultural family characteristics, play a role in forming expectations or valuing concerning a task or domain (Eccles & Wigfield, 2020; Fong et al., 2021; Gaspard et al., 2019; Rosenzweig et al., 2022). Although the relationship between motivational beliefs and science achievement has been studied by using a person-centered approach in both individualistic (e.g. Fong et al., 2021; Lee et al., 2022; Perez et al., 2019) and collectivistic (e.g. Ma, 2022) cultures there is a lack of research in a social context such as Türkiye, which exhibits both individualistic and collectivistic characteristics (Kağıtçıbaşı, 1994; Kahraman & Sungur-Vural, 2014).

Increasing students' motivation towards science is among the major goals of science curricula in most countries (Mullis et al., 2016). However, students' science motivational beliefs decrease in the middle school years (George, 2006; Liou & Liu, 2015). For this reason, the middle school years are a critical time period to investigate students' science motivational beliefs and the relations between gender, SES and motivational beliefs (Berger et al., 2020; Seçgin & Sungur, 2021).

This study aims to identify eighth grade students' motivation profiles and examine the relationships between motivation profiles and gender, socioeconomic status (SES), and cognitive levels of science achievement. This study has the potential to address and broaden understanding in four areas of the literature. One of these areas is a knowledge gap. In the studies examining the relations between science motivational beliefs and science achievement (e.g. Berger et al., 2020; Lee et al., 2022; Perez et al., 2019), science achievement was considered a homogeneous construct in terms of the cognitive dimension. Despite that, science achievement consists of three cognitive dimensions: 'knowing', 'applying', and 'reasoning'. The eighth-year science achievement scores in the 2019 TIMSS varied by cognitive dimensions (Mullis et al., 2020). Two research studies (Chang & Cheng, 2008; Liou & Liu, 2015) employing a variable-centered approach have been noted in the literature on this subject, and their findings have shown that motivational beliefs vary based on cognitive levels. Chang and Cheng (2008) examined 11th-grade students' science achievements at separate cognitive levels as knowledge and reasoning in Taiwan. They found that students' science interests and self-confidence were more positively associated with the knowledge domain. Similarly, Liou and Liu (2015) revealed that students' motivational beliefs in science learning (intrinsic interest, self-concept) were more highly correlated with the lower cognitive level (knowing) than with the higher cognitive level (reasoning). These studies highlighted the heterogeneous nature of science achievement and brought the need for such studies to the agenda (Liou & Liu, 2015).

Another gap is a methodological gap. Recent studies on the relationship between expectancy-value beliefs and science achievement have focused on identifying students' science motivational profiles by using a person-centered approach (e.g., Berger et al., 2020; Lee et al., 2022; Perez et al., 2019). However, these studies are limited in number and have been conducted in diverse cultural contexts (Canada, U.S., and Australia) and age groups (high school students, university students). Our study is valuable in that it examines a different culture with both individualistic and collectivistic traits and age group compared to those in the existing literature. Most research investigating the connection between expectancy-value beliefs and science achievement has utilized variable-centered approaches. Person-centered approaches provide integration of motivational aspects and consider the simultaneous changes between multiple motivation indicators in individuals (Fong et al., 2021). Students' expectancy (e.g. self-concept) and value beliefs (e.g. intrinsic value, utility value, cost) are considered to interact together to create motivational experiences that act as important predictors of academic achievement (Lee et al., 2022). In studies conducted with variable-centered approaches, one or two motivational beliefs could be focused on, which may limit the general understanding of science motivation. In contrast, person-centered approaches consider subgroup differences while exploring science motivational beliefs (Ma, 2022). None of the research examining the relationship of science motivation profiles with science cognitive dimensions was found in the literature.

The other gap is an evidence gap arising from conflicting results. According to SEVT, the opportunities provided to children and their decision-making situations may vary depending on the cultural context and specific groups within the same culture (e.g., gender, SES). Therefore, the cultural context has an impact on motivational beliefs (Tonks et al., 2018). Research has been carried out to explore the relationship between science motivational beliefs and gender in different cultural milieus. In these studies, there are inconsistent results in compared with motivational beliefs profiles and gender (e.g., Berger et al., 2020; Gaspard et al., 2019; Lee et al., 2022; Ma, 2022; Perez et al., 2019). One potential reason for this discrepancy could be gender equality (Liou et al., 2023). Investigating the connection between gender and science related motivational beliefs in a sample where gender equality, such as in Türkiye, is relatively low (World Economic Forum, 2021), could be effective in understanding the reasons for different results and providing insights into how cultural factors interact with gender to influence science motivational beliefs.

The last gap is also a knowledge gap. A few research (e.g., Radišić et al., 2021) was reached on the relationship between SES and science motivational beliefs profiles. It is crucial to examine the relationship between science motivational beliefs and SES using a person-centered approach, both to expand the body of knowledge on SEVT and to compare its results with variable-centered research.

Situated Expectancy Value Theory Perspective

In SEVT, two constructs—expectancy beliefs (learners' perceived competence in the relevant domain) and value beliefs (learners find the domain enjoyable and beneficial) predict academic achievement (e.g., Lee et al, 2022; Rosenzweig et al., 2022; Wigfield & Eccles, 2000).

Expectancy beliefs include the self-concept of one's abilities, which is related to a person's feelings about competence and self-efficacy beliefs (Eccles & Wigfield, 2002; Perez et al., 2019). Self-concept is a perception of one’s competence in a specific subject (Marsh & Shavelson, 1985). There are four components in SEVT that influence students’ task value: intrinsic value, attainment value, utility value, and cost (Eccles et al., 1983; Eccles & Wigfield, 2002, 2020). First of all, intrinsic value means that the individual enjoys performing a task (Wan, 2021; Wigfield & Eccles, 2000) and engages in a task for pleasure or satisfaction (Rosenzweig et al., 2022; Wigfield & Eccles, 1992). Secondly, attainment value is the identity-based importance of a particular task or subject (Eccles & Wigfield, 2020; Gaspard et al., 2019). Thirdly, utility value pertains to how well a task aligns with an individual’s current and future plans or needs (Eccles & Wigfield, 2020; Mullis & Martin, 2017; Wang & Liou, 2018). Fourthly, the cost is the individual’s perception of the difficulties s/he perceives for a task and what s/he must give up fulfilling the task (Eccles & Wigfield, 2002; Gaspard et al., 2019; Lee et al., 2022). As indicated in the limitations section, attainment value and cost could not be analysed, while the intrinsic value and utility value variables, which belong to task value beliefs, from the TIMSS 2019 data were investigated.

Students’ Science Motivational Beliefs and Science Achievement

There is a positive correlation between students’ motivation in science and their science achievement (Geesa et al., 2019; Liou et al., 2021; Topçu et al., 2016). This positive relationship also exists between intrinsic value, self-concept and utility value of science and science achievement, although at different magnitudes (Liou, 2017; Mullis et al., 2020; Wang & Liou, 2018). Both expectancy and value beliefs have been demonstrated to be very domain-specific (Fong et al., 2021; Gaspard et al., 2019). The intrinsic value of science denotes how much the student perceives science as an engaging domain and derives pleasure from studying and learning its content during leisure time (Miscevic-Kadijevic, 2015). Wang and Liou (2018) found that the predictive effect of intrinsic value on science achievement was larger than that of utility value. Enjoyment of science predicts participation in science-related activities currently and in the future (Ainley & Ainley, 2011).

Self-concept of science refers to the student’s positive/negative belief in his/her ability to learn science by observing other students and the teacher (Miscevic-Kadijevic, 2015). There exists a robust positive correlation between student’s academic self-concept and their science achievement (Mullis & Martin, 2017; Mullis et al., 2020; Wang & Liou, 2018). When compared to intrinsic and utility values, the effect of self-concept on science achievement is stronger (Liou & Liu, 2015; Liou, 2017). The utility value of science expresses the extent to which the student regards science as useful and important for student’s future plans and needs. As with other motivational beliefs, there is a positive correlation between utility value and science achievement (Liou, 2017; Mullis & Martin, 2017; Mullis et al., 2020).

In studies investigating the correlation between science academic achievement and expectancy-value beliefs using person-centered approaches, Perez et al. (2019) found that students in the moderate all profile tended to have lower STEM academic achievements than those with higher motivational beliefs. The cross-domain research using the TIMSS 2015 data about eighth-grade students carried out by Berger et al. (2020) revealed that students with more positive motivational beliefs for both areas had higher achievements. In Ma’s (2022) research on eighth-grade students in Hong Kong using the TIMSS 2015 data, five profiles of science motivational beliefs were obtained. Although the association was not exactly linear, learners in profiles with higher degrees of science motivational beliefs tended to demonstrate superior science achievement.

The Cognitive Dimensions of Science Achievement

Whilst students’ science achievement is generally accepted as a single homogeneous construct, science achievement has a heterogeneous structure in terms of cognitive domains (Liou & Liu, 2015). In the TIMSS assessments, science achievement is separated into three cognitive domains: knowing, applying, and reasoning. Knowing includes the student’s ability to remember, identify, describe and give examples. Applying comprises comparing and classifying information, relating it to a specific context, and solving practical problems. On the other hand, reasoning involves using evidence and science understanding to analyze, synthesize and generalize in complex contexts and unfamiliar situations. These cognitive domains involve a hierarchical thinking process from knowing and applying to reasoning (Mullis & Martin, 2017). These domains can be viewed as analogous to the cognitive processes in the Revised Bloom's Taxonomy (RBT). It can be assumed that knowing and applying correspond to the remembering, understanding, and applying domains of the RBT, while reasoning corresponds to the analyzing, evaluating, and creating domains (Gutvajn et al., 2011, as cited in Miscevic-Kadijevic, 2015). In the hierarchical process from knowing and applying to reasoning, higher-order cognitive skills are considered more valuable, as they require solving more complex tasks. In the higher-level cognitive domain, problem-solving ability is regarded as a more sophisticated skill than knowing simple and independent facts (Liou & Liu, 2015).

In the TIMSS 2019 results, the science achievement of eighth-grade students showed enormous changes between cognitive domains. In Singapore, which ranked first, the average scale scores of students were 621 for knowing, 608 for applying, and 595 for reasoning; in other words, the scores decreased from the lower level to the higher level. In the sample of Türkiye, which showed achievement close to the average, students' average scale scores were 506 in knowing, 515 in applying, and 524 in reasoning; so, the scores increased from the lower level to the higher level (Mullis et al., 2020). When the countries are compared within themselves, students in Singapore had more difficulty in the reasoning domain, while students in Türkiye had more difficulty in the knowledge domain. These circumstances can be considered as an indication that science cognitive domains are worth investigating.

Despite the limited number of studies in the literature (e.g., Liou & Liu, 2015) examining students' science achievements with their science motivational beliefs according to cognitive levels, there is no study that determines them with a person-centered approach. Chang and Cheng (2008) examined 11th-grade students' science achievements at separate cognitive levels as knowledge and reasoning in Taiwan. They found that students' science interests and self-confidence were more positively associated with the knowledge domain.

Gender and SES Differences in Science Motivational Beliefs

Considering that science-related fields are mostly preferred by males (Akgündüz, 2016; Moakler & Kim, 2014), that science is a male-dominated field (Banchefsky & Park, 2018; Kahraman & Sungur-Vural, 2014), that gender is associated with science achievement (Mullis et al., 2020) and science motivation (Wan, 2021). There is a need to improve girls' science skills in middle school years due to science-related career choices (Moakler & Kim, 2014). It is crucial to take into account gender differences in science motivational beliefs from the preadolescence period to the adolescence period (Liou et al., 2021).

Numerous empirical studies have been carried out to examine the relationship between science motivational beliefs and gender. However, complex results have been presented. There are different results regarding gender differences in science motivation. There are studies showing that girls have higher science motivation (e.g., Hong & Lin, 2011). There are also research studies indicating that boys' science motivation is stronger (e.g., Fong et al., 2021; Liou et al., 2021; Wan, 2021; Wan & Lee, 2017) and that there is no difference in science motivation between genders (Lee et al., 2022; Perez et al., 2019; Seçgin & Sungur, 2021).

In the study of Berger et al. (2020), self-concept differences in each profile were generally in favor of boys, while utility value differences were in favor of girls. There were no differences in profiles between genders in terms of intrinsic value. According to this research, while there was no significant difference in science interest between female and male students, girls valued science more and boys considered themselves more competent in science. In the study by Fong et al. (2021), while girls in High Math/High Science profiles were underrepresented, girls in High Math/Low Science profiles were more represented than boys. In the research of Ma (2022), the rate of boys classified into higher science motivation profiles was greater than girls, and research results did not demonstrate significant relations between gender and motivational profile membership (Lee et al., 2022; Perez et al., 2019).

The variation in gender differences in intrinsic value, self-concept, and utility value of science and science motivational beliefs may be due to the cultural context. According to SEVT, intrinsic value, self-concept, and utility value are related to the individual's cultural milieu (e.g., gender stereotypes), beliefs and behaviors of socializers (e.g., parents, teachers, and peers), prior experiences with achievement, and the perceptions and interpretations of these (Eccles & Wigfield, 2020; Wigfield & Eccles, 2000).

According to SEVT, gender, socio-economic, and cultural family characteristics are also related to the intrinsic value, self-concept, and utility value of science (Eccles & Wigfield, 2002; Wigfield & Eccles, 1992). The fact that students have access to educational resources at home and have parents who draw attention to the importance of science education plays an important role in their affective orientation and supports them in developing positive learning motivational beliefs (Chen et al., 2012). Previous variable-centered studies also showed a positive relationship between SES and science-motivational beliefs (Chen et al., 2012; Fleming & Malone, 1983; Hu et al., 2018). Radišić et al. (2021) found in their person-centered research that students with higher SES were more inclined to be part of higher motivational profiles.

The Present Study

In this study, the science motivational beliefs of the eighth-grade students were evaluated using a nationally representative sample of the TIMSS 2019 data in Türkiye. The curiosity that prompted this study was to reveal eighth-grade students' science motivational profiles, to examine the relationships of the gender and SES covariate variables with motivational profiles, and to observe whether students' motivational profiles differed according to the cognitive dimensions of science achievement.

In this way, the research study will enhance understanding of motivational belief profiles in cultural context and help articulate the relationship of these profiles with the variables of SES, gender, and cognitive dimensions of science achievement. Based on the potential contributions to building on existing literature, this study aims to ascertain the latent profiles revealed by the answers given to the science-related questionnaires of the eighth-grade students who participated in TIMSS 2019 from Türkiye with latent profile analysis. For this purpose, it was determined whether socio-economic status (SES) and gender predicted profile membership. In addition, it was determined whether there were notable variances in student's achievements across cognitive domains (knowing, applying, and reasoning) in profile memberships that included SES and gender as covariates. The research questions are below:
Q1: How many profiles are there among students in terms of science motivation?
Q2: How do students' gender and socio-economic status predict motivational beliefs profile memberships?
Q3: How are students' motivational beliefs profiles associated with science knowing, applying, and reasoning achievement?

METHOD

Dataset and Sample

The dataset was obtained from the 2019 application of the TIMSS eighth-grade students administered by the International Association for the Evaluation of Educational Achievement (IEA). These students participated in the TIMSS 2019 from Türkiye and answered the science-related motivational beliefs scales and science achievement tests. The dataset initially consisted of 4048 students. Little's MCAR test was performed to determine whether the missing data were completely random, and the results indicated that the missing data followed the Missing Completely at Random (MCAR) model (χ^2 = 13.943, df = 15, p = 0.530), with less than 5% missing for each variable. Therefore, it is acceptable to exclude individuals with missing data from the analysis using complete case analysis. As a result, the dataset was reduced to 3988 students. Among these students, 1982 (49.7%) were female, while 2006 (50.3%) were male. The gender and SES variables were considered covariate variables. In the TIMSS, the scale of "Home Educational Resources" included information about the educational and occupational background of parents, the number of books at home, internet access, and room for students at home (see Mullis et al. (2016) for details about the index). This variable represents the participants' socioeconomic status (Gustafsson et al., 2018).

Instruments

The data were collected with the "Students Like Learning Science (SLLS)" scale consisting of nine items for students' intrinsic values (e.g., I look forward to learning science in school), the "Students Confident in Science (SCS)" scale consisting of eight items for students' self-concepts (e.g., I usually do well in science), and the "Students Value Science (SVS)" scale consisting of nine items for utility values (e.g., I think learning science will help me in my daily life). In this study, the structural validity and reliability of the scales were found to be satisfactory. For the SLLS, structural validity indices indicated a good fit (CFI = 0.98, TLI = 0.98, RMSEA = 0.06, SRMR = 0.03), and Cronbach's alpha value was 0.87. Similarly, the SCS demonstrated good structural validity (CFI = 0.98, TLI = 0.98, RMSEA = 0.05, SRMR = 0.02), with a Cronbach's alpha value of 0.85. Finally, the SVS showed good structural validity as well (CFI = 0.98, TLI = 0.97, RMSEA = 0.07, SRMR = 0.03), and its Cronbach's alpha value was 0.89.

To obtain the scale scores of the students, the IEA has used the Rasch partial credit model, which is one of the item response theory scaling methods. The items were calibrated by using data from all countries that have participated in TIMSS (Martin et al., 2016). The IEA-calculated scale scores of students were used with no transformations or changes made to the values. According to the IEA (2019), the science assessment framework for TIMSS 2019 is organized around two dimensions: (1) the Content dimension, specifying the subject matter, and (2) the Cognitive dimension, specifying the thinking processes to be assessed. Each student has five plausible values and the mean of the scores was scaled to 500, and the standard deviation was 100. TIMSS utilizes IRT scaling to place achievement in each of the cognitive domains on the TIMSS science achievement tests (Mullis et al., 2016). Three cognitive domains were examined in TIMSS, namely knowing, applying, and reasoning. Questions associated with these cognitive domains were devoted in the test to 35% of knowing, 35% of applying, and 30% of reasoning.

Data Analysis

The primary analysis technique of this study was latent profile analysis (LPA) with covariates. LPA, a person-centered approach, was utilized to classify individuals into different subgroups based on their response patterns, ensuring that individuals within a subgroup were more similar to each other than to those in other subgroups (Muthen & Muthen, 2000). In LPA, the number of latent subgroups was not determined a priori. For this reason, the analysis should be repeated until the fittest model for the data was reached, and the models tried in this process should be compared both in terms of statistical results and logical interpretability. It can be stated that some of the criteria mentioned in the literature for model selection were Akaike's Information Criterion (AIC; Akaike, 1974), Bayesian Information Criterion (BIC; Schwarz, 1978), Adjusted Bayesian Information Criterion (aBIC), Vuong-Lo-Mendell-Rubin Test (VLMRT; Lo et al., 2001) and entropy. 2 to 8 class models were tested, and model parameters were compared to find the best fit for the data. To statistically evaluate the model fit for different profiles, there were log-likelihood, AIC, BIC, adjusted BIC (aBIC), VLMR-LRT p-value, LMR p-value, and entropy criteria. Nylund et al. (2007) recommended using the Bayesian Information Criterion (BIC) to identify the best-fitting model, noting that a lower BIC value indicates a better model. On the other hand, Tein et al. (2013) highlighted that entropy and AIC values may be unreliable criteria. Therefore, this study primarily relied on BIC and the interpretation of profiles as the fundamental criteria for model selection. In the study, we used the “Total Student Weight” variable along with the motivational belief variables in the TIMSS dataset, as this procedure would increase the generalizability of the statistical estimations (Gonzalez, 2012).

After the model decision, we designated the profiles by interpreting the mean scores of the SLLC, SCS, and SVS variables in different profiles. Furthermore, we added "gender" and "SES" to the model as covariates. Finally, it was determined whether the student's performance in science cognitive domains (knowing, applying, and reasoning) differed statistically between different profiles using the distal outcome model. Due to its matrix-sampling booklet design, TIMSS employs multiple imputation to measure students' academic achievement. For the science cognitive dimensions, TIMSS provides five plausible values (PV1-PV5). Plausible values (PVs) are imputed values for latent variables (Asparouhov & Muthén, 2010), designed to reflect the uncertainty in estimating student achievement from the sampled data. The imputation method was used in the analysis by specifying TYPE=Imputation in Mplus, which facilitates the integration of all five plausible values into the analysis. The results were obtained by using Asparouhov and Muthén's manual BCH approach (2014). Furthermore, the Z-test was used to determine the mean differences between profiles, testing the null hypothesis that the means of two groups are equal, with statistical significance typically set at 0.05. The effect size was calculated using Cohen’s d, which is interpreted as small (0.2), medium (0.5), and large (0.8) effects, as suggested by Cohen (1988). All analysis was done with Mplus (Muthen & Muthen, 1998-2017).

RESULTS

Preliminary Analysis

Before performing the LPA for determining the students’ motivational beliefs profiles for science, descriptive statistics of variables and the correlation coefficients between the variables were listed in Table 1. The TIMSS measured the eighth-grade students’ intrinsic values with the SLLS scale, their self-concepts with the SCS scale, and their utility values with the SVS’ scale.

Table 1.
Means and Correlations between Variables

Variables	$\underline{X}$	SD.	Skew.	Kur.	IV	SC	UV	SES	Knowing (PV)	Applying (PV)	Reasoning (PV)
IV	10.73	1.91	-.25	-.15	1						
SC	10.83	2.14	.32	.02	.64**	1					
UV	10.35	1.85	-.43	.15	.56**	.42**	1				
SES	9.38	1.80	-.14	.23	.03	.21**	.04**	1			
Knowing (PV)	501.93	106.14	-.22	-.04	.25**	.46**	.14**	.47**	1		
Applying (PV)	510.83	94.21	-.12	-.18	.23**	.47**	.11**	.47**	.89**	1	
Reasoning (PV)	520.02	99.73	-.26	.01	.22**	.45**	.10**	.45**	.88**	.88**	1

*SD: Standard deviation; Skew: Skewness; Kur: Kurtosis; IV: Intrinsic Value; UV: Utility Value; SC: self concept; Mean values of PV reported. ** p<.01*

Table 2 showed the descriptive statistics of intrinsic value, self-concept, utility value, SES, and PV of knowing, applying, and reasoning. All variables showed normal distribution. The mean scores for the intrinsic value, self-concept, and utility value variables were close to each other. All correlation coefficients were significant at p < .01 except between SES and intrinsic value. The magnitudes of correlations between knowing, applying, and reasoning was strong (r = .88 - .89), while correlations between intrinsic value, self-concept, and utility value show moderate (r= .42 - .64).

Latent Profile Analyses

In order to reveal the students' motivational profiles and to find the model enabling meaningful interpretations, LPA was performed from one profile to eight profiles (see Table 2 for the model).

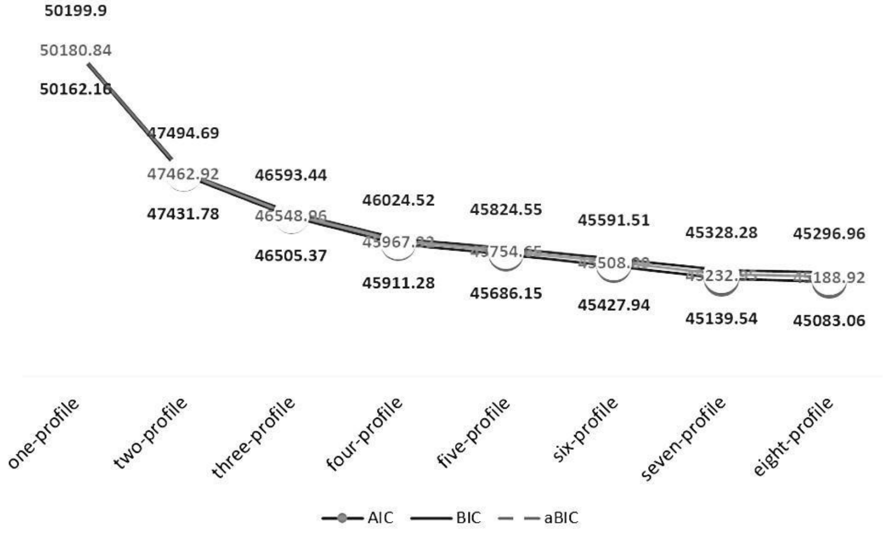
Table 2.
Latent Profile Analysis Results and Fit Statistics

Model	k	LL	Npar	AIC	BIC	aBIC	p (VLMR-LRT)	p(LMR-ALRT)	Entropy
1 Profile	1	-25075.08	6	50162.16	50199.90	50180.84	-	-	1
2 Profile	2	-23705.89	10	47431.78	47494.69	47462.92	<0.01	<0.01	0.72
3 Profile	3	-23238.68	14	46505.37	46593.44	46548.96	<0.01	<0.01	0.81
4 Profile	4	-22937.64	18	45911.28	46024.52	45967.32	<0.01	<0.01	0.80
5 Profile	5	-22821.07	22	45686.15	45824.55	45754.65	<0.01	<0.01	0.80
6 Profile	6	-22687.97	26	45427.94	45591.51	45508.89	0.57	0.61	0.79
7 Profile	7	-22539.77	30	45139.54	45328.28	45232.95	0.48	0.53	0.89
8 Profile	8	-22507.53	34	45083.06	45296.96	45188.92	0.19	0.20	0.86

Note: k=class number; -LL= model Loglikelihood; Npar= number of parameter; AIC = Akaike information criterion; BIC = Bayesian information criterion. aBIC = adjusted BIC; Bootstrap LRT (p value); LRT=Lo–Mendel–Rubin (p value)

The AIC, BIC, and aBIC values exhibited a consistent decrease across each Latent Profile Analysis (LPA) model (see Table 2). A notable convergence of these metrics is observed beyond the four-profile model, indicating an inflection point. This observation is visually supported by Figure 1. Assessing the statistical significance through the VLMLRT and adjusted LRT tests, it is determined that the inclusion of a sixth profile does not yield a significant enhancement in model fit over the five-profile model ($p = .574$ and $p = .611$). This situation necessitated a decision-making process between the four-profile and five-profile models by considering both the statistical findings and the logical alignment of their structures with the relevant literature. Although the five-profile model exhibits slightly lower AIC, BIC, and aBIC values, the difference in these metrics between the four-profile and five-profile models is not substantial. Notably, the entropy values for profiles 4 and 5 are consistent (see Table 2). Within the context of the five-profile model, a specific profile emerges, representing individuals with very low motivation and accounting for approximately 1% of the total population. Individuals within this profile constituted a very small portion of the population and did not exhibit any characteristics of significance that would contribute to the relationships explored in the study or the broader literature. When examining the cut scores of the scales used to uncover latent classes in this study, as reported in the TIMSS 2019 International Results (Mullis et al., 2020), the profiles in the four-profile model sufficiently captured the entire range of cut score variability, making additional profiles unnecessary. Furthermore, although two profiles in the four-profile model displayed similarities in their average intrinsic value and utility value, one of these profiles was significantly distinct from the other in terms of self-concept averages, as determined by cut scores. Liou and Liu (2015) and Liou (2017) emphasized that the effect of self-concept on science achievement is stronger compared to intrinsic and utility values. This insight further motivated our interest in examining the profile differentiated by self-concept. Conversely, no evidence suggested that analyzing the five-profile model would yield greater contributions to the literature than the four-profile model. In conclusion, the selection of the four-profile model was well-supported by several factors: the meaningful differentiation of average scores across profiles, as highlighted by considerations of scale cut scores, the model's alignment and interpretability in relation to existing literature, and its superior fit to the data when compared to all other models—apart from the debated five-profile model. Thus, the four-profile model was finalized as the most appropriate solution, with the following fit indices: log-likelihood = -22937.642, AIC = 45911.283, BIC = 46024.522, aBIC = 45967.326, and entropy = 0.800, supported by significant LMR and VLMR tests ($p < .001$).

Figure 1.
AIC, BIC and aBIC Values for Eight Different Latent Profile Models



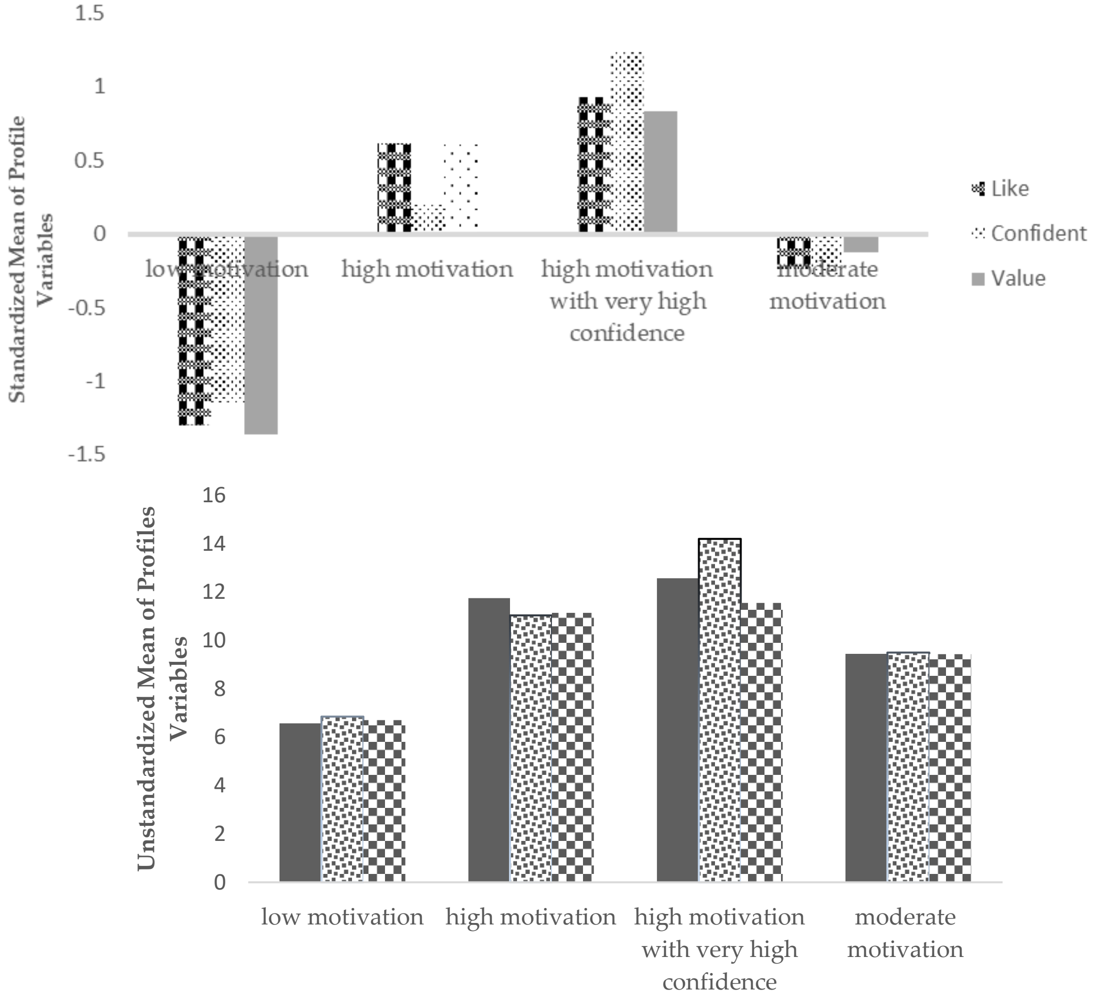
Based on the eighth-grade cut scores reported in the TIMSS 2019 International Results (Mullis et al., 2020), attitudes were categorized as follows: low attitudes (less than ~9), moderate attitudes (~9 to ~11), and high attitudes (greater than ~11). These thresholds, derived from intrinsic value, self-concept, and utility value scores, represent general patterns across scales with slight variations among domains. When examining the mean values across the profiles in the four-profile model (see Table 3), distinct patterns emerged. Profile One (Low Motivation) exhibited mean values significantly below the approximate thresholds for all domains, with intrinsic value = 6.575, self-concept = 6.845, and utility value = 6.700, categorizing this group as low attitudes. This group also accounted for only 3% of the population. Profile Four (Moderate Motivation) demonstrated mean values around the moderate range, with intrinsic value = 9.443, self-concept = 9.501, and utility value = 9.436. Representing the largest proportion of the population (43%), this group reflects a somewhat motivated perspective. Profile Two (High Motivation) exceeded the threshold for high attitudes, with intrinsic value = 11.743, self-concept = 11.039, and utility value = 11.144. This profile aligns closely with high motivation and covered 36% of the population. Finally, Profile Three (High Motivation with Very High Confidence) demonstrated the highest scores across all domains, with intrinsic value = 12.571, self-concept = 14.201, and utility value = 11.556. This group clearly fell into the high range, particularly standing out for self-concept, and accounted for 18% of the population.

The labels assigned to each profile reflect these patterns, capturing meaningful distinctions in intrinsic value, self-concept, and utility value. Table 3 presents the unstandardized means for the variables across the four profiles, while Figure 2 illustrates the standardized-unstandardized scores for these variables.

Table 3.
Mean Levels on The Profile Indicators

Profiles	Intrinsic value	Self-concept	Utility value	%
Profile One: Low motivation	6.575	6.845	6.700	3
Profile Two: High motivation	11.743	11.039	11.144	36
Profile Three: High motivation with very high confident	12.571	14.201	11.556	18
Profile Four: Moderate motivation	9.443	9.501	9.436	43

Figure 2.
Unstandardized and Standardized Means of Motivational Beliefs Profiles



Profile Membership Based on Students' Gender and SES

We considered the students' gender and SES predicted their profile memberships in the LPA model (see Table 4). All comparisons based on profiles are in Appendix A. The gender variable was coded as a dummy variable (female=0, male=1). Profile 4 was chosen as the reference group. The multinomial logistic regression results showed that gender was associated with class membership. As shown in Table 4, in the high motivation and high motivation with very high confident profiles, statistically significant coefficients were obtained. It means that the boys were less likely to be assigned to the high motivation or high motivation with very high confidence. The students with high SES were statistically more likely to belong to high motivation and high motivation with very high confidence than to moderate motivation. This result showed that the students with high SES were likely to be in the high motivation profiles. Moreover, there was no significant association between their likelihood of being classified as low motivation versus moderate motivation.

Table 4.
Results of LPA for Four-Profile with Covariates

	Profile 1 versus Profile 4				Profile 2 versus Profile 4				Profile 3 versus Profile 4			
Covariates	Est.	SE	Int.	Odds [SE]	Est.	SE	Int.	Odds [SE]	Est.	SE	Int.	Odds [SE]
Gender	-0.14	0.3	-2.5	0.91[.21]	-0.24*	0.1	-0.1	0.79 [.08]	-.26*	0.1	-0.6	0.77[.08]
SES	0.03	0.1	-2.9	1.03 [.05]	.056*	0.02	-0.7	1.06 [.41]	.29*	0	-3.7	1.34[.04]

** p<.05; Profile 1 = low motivation; Profile 2 = high motivation; Profile 3 = high motivation with confidence, Profile 4= moderate motivation*

Associations of Profiles with Students' Science Achievement

Finally, we investigate whether the students' motivation profiles were related to their cognitive domains of science achievement and their gender and SES. The students with low motivation profiles had the low achievement in science across all cognitive domains, and they were followed by those with moderate motivation, high motivation, and high motivation with very high confidence. When the gender and SES variables were controlled, the "low motivation in science" and "moderate motivation in science" profiles had no significant difference in their science achievement domains (Table 5). However, students' motivation profiles influenced their achievement in Science cognitive dimensions. The most significant differences were identified between the low motivation and high motivation with confidence in science applying (d=1.447). Additionally, large differences were found between the low motivation and high motivation with confidence in science knowing (d=1.368), as well as the low motivation and high motivation with confidence in science reasoning (d=1.357).

Table 5.
Pairwise Mean Differences in Across Profiles (BCH Method)

Science Cognitive Dimensions	Profile comparison (μ1-μ2)	Δμ	Z	Cohen d
Knowing	P1 vs P2	-58.186	12.953*	0.606
	P1 vs P3	-131.341	13.723*	1.368
	P1 vs P4	-9.791	12.396	-
	P2 vs P3	-73.155	5.415*	0.762
	P2 vs P4	48.395	5.054*	0.504
	P3 vs P4	121.550	5.055*	1.266
Applying	P1 vs P2	-67.833	13.802*	0.793
	P1 vs P3	-126.300	14.741*	1.447
	P1 vs P4	-21.788	13.900	-
	P2 vs P3	-58.466	5.031*	0.684
	P2 vs P4	46.045	5.38*	0.538
	P3 vs P4	104.511	5.282*	1.222
Reasoning	P1 vs P2	-59.659	11.351*	0.655
	P1 vs P3	-123.621	12.448*	1.357
	P1 vs P4	-15.815	11.532	-
	P2 vs P3	-63.692	5.570*	0.702
	P2 vs P4	43.844	4.606*	0.481
	P3 vs P4	107.806	4.979*	1.183

*Note: *< 0.001 Δμ: Mean difference; μ1-μ2: the difference between the mean of profiles; Profile 1 = low motivation; Profile 2 = high motivation; Profile 3 = high motivation with confidence, Profile 4= moderate motivation*

DISCUSSION

In this study, our goal was to reveal the relationship between students' science motivation profiles and significant differences between the student's achievements in the cognitive domains in profile memberships that included SES and gender as covariates.

Profiles of Students' Science Motivational Beliefs Profiles

According to SEVT, there are gender differences in the relationships between achievement and motivational beliefs. Previously, it was found that different profiles emerged in person-centered research on motivation toward science (e.g. Berger et al., 2020; Bøe & Henriksen, 2013; Snodgrass Rangel et al., 2020). The reason for the emergence of different profiles may be different samples and cultures. We found four motivational beliefs in science: "low motivation", "moderate motivation", "high motivation", and "high motivation with very high confidence". The findings indicated that there was a very small group (3%) with low motivational beliefs in science, while the group with the highest percentage had a moderate motivational beliefs profile. Moreover, the group with high motivational beliefs constituted about 55% of the sample. The profiles of the study were as expected from SEVT. This result was consistent with the other person-centered studies examining mathematics and science motivational beliefs profiles conducted by Berger et al. (2020) and Snodgrass Rangel et al. (2020). They found a small group with low motivational beliefs, and a higher rate of high motivational beliefs, not consistent with Gaspard et al. (2019). However, these studies found students' profiles by combining two different subjects such as math, science, and English. Taken together, there was a variety in the motivational beliefs' profiles of the students; however, the majority of them were high profiles. In other words, more than half of the group in this sample was found to have positive motivational beliefs toward science. One of the reasons for the high proportion of high motivational beliefs may be that the majority of the students in this sample had to participate in the high-stake test application that had a science subject for the transition to high school.

The high motivational beliefs with a very high confidence profile comprised a smaller percentage compared to the moderate and high-profile groups at the patterns of motivational beliefs. In addition, the difference between high motivational beliefs and high motivational beliefs with very high confidence profiles was that the intrinsic value and utility value were almost at the same level. However, self-concept was thought to be a more extrinsic component compared to the others. Interestingly, this result was not consistent with findings from other person-centered research examined motivational beliefs based on SEVT (e.g., Berger et al., 2020; Lee et al., 2022). It revealed that science achievement was one of the results frequently encountered in the literature (e.g., Acar, 2019; Mullis & Martin, 2017; Wang & Liou, 2018). Therefore, the self-concept variable may have diverged from the other variables. Furthermore, it was found that the students with high self-concept had significantly higher average achievements than those with low self-concept. The relationship between the utility value of science with achievement was weaker than that of the intrinsic value and self-concept variables (Mullis et al., 2020). It was examined whether there was a difference between the profiles depending on the cognitive domains, but the science subject areas were not taken into account since science courses were given combined in the secondary school curriculum in Türkiye. However, as noted in the TIMSS 2019 report, it was found that science motivational beliefs varied in the subject areas of biology, chemistry, physics, and earth science (Mullis et al., 2020). In addition, it was found that the intrinsic value, utility value, and self-concept variables were generally (very) high or (somewhat) moderate for both Türkiye and international averages.

Gender and SES as Predictors of Students' Science Motivational Beliefs Profiles

We investigated differences in profile memberships based on gender and SES. It was found that the boys were less likely than the girls to have "high motivation" and "high motivation with very high confidence" profiles. This result was inconsistent with the results of different studies using the person-centered method, in which boys had high motivation profiles (Fong et al., 2021; Ma, 2022) or there was no significant difference between boys and girls (e.g., Lee et al., 2022; Perez et al., 2019). The results of gender differences in science motivational beliefs in studies using variable-centered methods were not very consistent, either. Several studies reported that boys had more positive science motivational beliefs than girls (e.g., Hu et al., 2018; Liou et al., 2021; Wan, 2021). While a study using the 2011 TIMSS data from 45 countries, no significant difference was found in the science motivation of girls and boys (Bodovski et al., 2020). On the other hand, our results, in which the girls had high motivation profiles, were evaluated in the literature as unconventional results (Liou et al., 2021). Our findings align with those of Hong and Lin (2011), who conducted their research with a sample from Taiwan, as well as with the 2015 TIMSS results for Türkiye reported by Liou et al. (2023). In their study, Liou et al. (2023) observed that boys' motivational beliefs in science were either higher or showed no significant difference compared to girls' beliefs in societies with relatively high gender equality. However, in Middle Eastern societies (e.g., Saudi Arabia, Kuwait, Oman, and Türkiye) where gender equality is low, girls' motivational beliefs in science were high. According to the Global Gender Gap Index 2021 rankings, Türkiye ranked 133 out of 156 countries in terms of gender equality (World Economic Forum, 2021). The reason why girls have a high motivation in science in Türkiye might be answered, where gender equality is low, education may be an important tool for women's emancipation. Education is an important area of opportunity for girls to demonstrate that they are equal to boys. This leads girls to have positive motivational beliefs toward courses. The TIMSS results also support these inferences. There is a reciprocal relationship between academic self-concept and academic achievement (Marsh & Martin, 2011). In Türkiye, Kuwait, Oman, and Saudi Arabia, in the last three TIMSS cycles (Kuwait did not participate in the 2011 assessment), the average achievement of girls in both science and mathematics was higher than that of boys in the eighth-grade results (Mullis et al., 2020).

It was found that students from high SES backgrounds were more inclined to be part of the high-motivation groups. This finding especially supports the results of variable-centered research using relatively large samples such as TIMSS (e.g., Chen et al., 2012; Hu et al., 2018) as well as the principle of SEVT regarding that socio-economic family characteristics are related to expectancy and value beliefs. Since the subject of science based on real-life situations, it was recommended that students should benefit from out-of-school learning environments (e.g., science centers, museums, planetariums, zoos, botanical gardens, and natural environments) for an effective learning process in the 2018 Turkish Science Curriculum, (MoNE, 2018). However, being able to benefit from out-of-school learning environments requires a cost, and students with higher SES levels are more likely to have these environments. Richness of experience based on scientific phenomena, optional science experiences (Liu & Schunn, 2020), technology-based applications, such as augmented reality (Çetin & Türkan, 2021), and parental involvement (Gorard & See, 2009) enhance science motivation in a positive way. Compared to families with a low SES level, those with a high SES level have a greater opportunity to offer a conducive environment for learning, a variety of learning materials, technological equipment, and informal learning opportunities, such as summer schools and STEM camps (Liu & Schunn, 2020), and schools that are better equipped with technology and learning materials. It can be thought that these reasons may have been important in the development of positive motivational beliefs toward science.

Students' Motivational Beliefs Profiles and Science Cognitive Dimensions

When we look at the distal outcomes comparisons of the students from different profiles, some results stand out. The mean scores of the students from the science achievement test increased from the lowest motivation group to the highest motivation group in all cognitive domains. The differences between the mean scores of the students in different motivational beliefs profiles were statistically significant in all other pairwise comparisons, except for the comparisons between the low and moderate motivation profiles. The fact that the difference between the low and moderate motivation profiles was not statistically significant and that the differences between the high motivation and other profiles were, however, statistically significant indicates that motivation in science must reach high levels to have a significant association with science achievement. This situation reveals the importance of having a high-level motivation for achievement in all cognitive domains (knowing, applying, and reasoning) in science. Another remarkable result was that the mean scores of the students in the "high motivation with very high confidence" profile in three domains were quite higher than those in the other profiles because there was no big difference between this profile and the "high motivation profile" in terms of intrinsic and utility value, but there was a noticeable difference in terms of self-concept. This showed us that the profile of the students with high self-confidence performed well in all cognitive domains. In the literature review, we found studies showing that there was a positive and strong relationship between self-concept and science achievement, and that self-concept was a more effective predictor of achievement than other motivational beliefs variables (Acar, 2019; Liou, 2017; Liou & Liu, 2015; Mullis et al., 2020; Wang & Liou, 2018). It should be noted that our study did not resolve the uncertainty arising from the duality of the relationship. We could not know whether the students had high science achievements because their motivation in science was high or whether the students with high science achievements were assigned to latent classes with a high motivation profile because their motivational beliefs were also high. Although a definite interpretation cannot be made on this subject, the relationship examined in this study was from motivation to success. If we had tested the statistical significance of the differences in motivation levels between the achievement profiles, the analysis would have been from achievement to motivation. In this respect, at least, we know that the students who were different from each other in terms of science motivation levels were also different from each other in terms of science achievement and that the difference between their motivational beliefs explains the difference between their achievements. Besides, no conclusion could be reached regarding the advantages or disadvantages of different motivational belief profiles in different cognitive domains. It was determined that the mean scores of the reasoning domain in all motivational beliefs' profiles were higher than the mean scores of the other domains.

CONCLUSION

Overall, the main focus of the current study was to identify Turkish adolescents/students' motivational beliefs profiles toward science. There are other studies aimed at determining the motivational beliefs profiles of students/adolescents in science (e.g., Berger et al., 2020). However, this is the only study to examine science belief profiles using science cognitive domains (knowing, applying, and reasoning) with SES and gender by using a nationally representative sample. LPA revealed four science motivation profiles, namely "low motivation", "moderate motivation", "high motivation", and "high motivation with very high confidence". Gender and SES were found to be important for the likelihood of having high motivation profiles (Profiles 2 and 3). In other words, the girls were more likely to have higher profiles and the boys were more likely to have lower profiles, while the students with higher SES were more likely to have high motivational beliefs profiles. The results of this study challenge gender the stereotype that males have higher preferences for science. When considered together with the results of other studies conducted in different cultures (e.g., Liou et al., 2023), it can be concluded that culture is more influential in science than innate characteristics as assumed in SEVT (Eccles & Wigfield, 2020). While there was no significant difference between the "low motivation" and "high motivation" profiles for science knowing and science applying, there was a difference in all other pairwise comparisons. It was determined that the science knowing, applying and reasoning scores differed significantly among the profiles and that there were significant differences in each domain between the high and moderate profiles. In addition, when gender and SES were added to the model, there was no difference between the low and moderate motivation profiles in knowing, applying, and reasoning. However, there were differences between all other profiles. The results of the study emphasize the importance of considering students' SES and gender in a culture, where both traditional collectivist and individualistic cultures coexist, and show that it is distinctive, especially in high-confidence profiles.

Educational Implications

The results of this study have implications. Firstly, there is a centralized education system in Türkiye and this prevents teachers, who are practitioners, from taking contextual differences in the curriculum into account. However, when the teacher requires it, it may be necessary to make revisions in classroom practices by taking into account differences in students' motivation in the subject, course, gender, and SES. In other words, the teacher should have sufficient flexibility and self-determination. With the person-centered approach, students' motivational beliefs were handled in a multi-dimensional way. Our results revealed that the students' science motivational beliefs were divided into four profiles and that more than half of the students were classified as having a high-level attitude profile. These students also had the highest course grades; nearly half of them were classified as having a low and moderate-level attitude profile; and these students had low grades. For this purpose, carrying out activities that may enable the development of positive motivation in science in classrooms and schools by integrating various learning materials, technological equipment, enrichment opportunities of learning environments, such as STEM camps (Liu & Schunn, 2020) and course studies (Snodgrass Rangel et al, 2020), will increase students' science motivation and achievements. In addition, by determining the level of students' motivation in science, and if they have a low level, the reason for this, solutions aimed at increasing their motivation can be sought by conducting interviews with the teacher or psychological counselor. Moreover, it was also found that self-concept was dissociated from the other attitude constructs. Considering that self-concept is formed by observing other students and the teacher

(Miscevic-Kadijevic, 2015), it is suggested that the classroom and school environment are important in the development of students' motivation in science, and it is recommended that teachers consider motivation and differences in motivation, which are important predictors of science achievement. In addition, gender and SES were found to be important for the likelihood of having high motivation profiles. For this reason, educators should consider students' gender and SES when organizing science activities.

Limitations and Future Research

We acknowledge that this study has certain limitations that should be considered in future research when the findings are interpreted. Firstly, we assumed that the student's responses to the science motivation questionnaires reflected their actual thoughts. Secondly, sample of this study was the nationally representative sample and data obtained from other countries, cultures, or age groups were ignored in TIMSS 2019. Consequently, caution should be exercised when generalizing the findings of this study. Thirdly, the four components in SEVT, namely intrinsic value, attainment value, utility value, and cost influence students' task values (Eccles et al., 1983; Eccles & Wigfield, 2020). Attainment value and cost could not be examined within the scope of this research because they were not included in the data on motivational belief in TIMSS 2019. In addition, only the field of science was chosen in this study, and future research can thus reveal students' profiles based on expectancy-value theory by combining other fields, such as mathematics and literary, which are related to science. In future studies, it would be very interesting to reveal whether these results can be replicated for the same or different cultures, geographical regions, or age groups. Fourthly, a single-level LPA was used to reveal the students' science profiles, and in future studies, a multi-level LPA can be performed by considering the multi-level structure of the data. Fifthly, the intrinsic value, self-concept, and utility value constructs, measured by scale items used in TIMSS, were used. In future studies, research findings can be compared by using different scales that measure the same constructs. Sixthly, in education systems that deal with science in separate subject areas, such as biology, chemistry, and earth science, the profiles of students for different subject areas can be revealed, and it can be examined whether these profiles differ in different subject areas. At the very least, TIMSS is a cross-sectional study, and therefore, in future research, longitudinal studies can be conducted to reveal the profiles of science motivational beliefs and their relationship with science achievement. As a continuation of this study, it will be very interesting to examine the stability of science profiles of students, the relationship between SES and gender with profiles, and the relationship between the science cognitive domain throughout high school and university. In addition to quantitative studies, mixed research can be conducted with qualitative methods such as observation and interviews.

Disclaimer

The author, Cigdem Akin Arikan, conducted this work independently, relying solely on their own research, analysis, and interpretation. The views and opinions expressed in this work are personal to the author and should not be considered as reflecting the official policy or position of the organization mentioned.

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TÜRKÇE GENİŞLETİLMİŞ ÖZET

Bu çalışma, öğrencilerin motivasyon profillerini belirlemeyi ve motivasyon profilleri ile cinsiyet, sosyo-ekonomik durum (SES) ve fen bilimleri bilişsel alan becerileri (bilme, uygulama, akıl yürütme) arasındaki ilişkiyi incelemeyi amaçlamaktadır. Bu çalışma, alanyazındaki bir takım boşlukları ele alma ve oralardaki sınırlı bilgiyi genişletme potansiyeline sahiptir. Söz konusu boşluklardan birisi bilgi açığıdır. Fen motivasyonel inançları ile fen başarısı arasındaki ilişkileri inceleyen çalışmalarda (örn. Berger vd., 2020; Lee vd., 2022; Perez vd., 2019), fen başarısı tek boyutlu homojen bir yapı olarak değerlendirilmiştir. Bu çalışmada fen başarısı üç bilişsel alan basamağı uyarınca üç boyutta ele alınmıştır: “bilme”, “uygulama” ve “akıl yürütme”. TIMSS 2019 uygulamasında sekizinci sınıf öğrencilerinin fen başarıları söz konusu üç bilişsel alan boyutu üzerinden ele alınmıştır (Mullis vd., 2020). Bir diğer boşluk ise metodolojik boşluktur. Beklenti-değer inançları ile fen başarısı arasındaki bağlantıyı araştıran çoğu araştırmada değişken-merkezli (variable-centered) yaklaşımlar kullanılmıştır. Diğer yandan, bu araştırmada da benimsenen yaklaşım olan birey merkezli (person-centered) yaklaşımlarla, motivasyon bileşenlerinin eş zamanlı olarak incelenebilmesi ve bireylerdeki birden fazla motivasyon göstergesinin değişiminin dikkate alınması mümkün hale getirilebilir (Fong vd., 2021). Alanyazındaki bir diğer boşluk ise çelişkili sonuçlardan kaynaklanan kanıt yetersizliğidir. Beklenti Değer Teorisi’ne göre çocuklara sağlanan fırsatlar ve çocukların karar verme durumları, kültürel bağlama ve aynı kültür içindeki belirli gruplara (örneğin cinsiyet, SES) bağlı olarak farklılık gösterebilmektedir. Farklı kültürel ortamlarda fen motivasyonel inançları ile cinsiyet arasındaki ilişkiyi araştırmak için yapılan çalışmalarda motivasyonel inanç profilleri ve cinsiyet ilişkisi konusunda tutarsız sonuçlar bulunmaktadır (örn., Berger vd., 2020; Gaspard vd., 2019; Lee vd., 2022; Ma, 2022; Perez vd., 2019). Bu farklılığın potansiyel nedenlerinden biri cinsiyet eşitliği olabilir (Liou vd., 2022). Türkiye gibi cinsiyet eşitliğinin nispeten düşük olduğu bir örneklemde (Dünya Ekonomik Forumu, 2021) cinsiyet ve fen motivasyonel inançları arasındaki bağlantının araştırılması, farklı sonuçların nedenlerinin anlaşılmasında ve kültürel faktörlerin nasıl gerçekleştiğine dair içgörü sağlanmasında etkili olabilir.

Yapılan tartışmalardan hareketle bu çalışmada, Türkiye'deki TIMSS 2019 verilerinin ulusal temsili bir örneği kullanılarak 8. sınıf öğrencilerinin fen bilimlerine yönelik motivasyonel inanç profilleri ile fen başarıları arasındaki ilişkiler incelenmiştir. Bu inceleme yapılırken cinsiyet ve sosyo-ekonomik düzey değişkenlerinin etkileri de göz önünde bulundurulmuştur. Bu bağlamda araştırma, kültürel bağlamda (lokal) motivasyonel inanç profillerinin anlaşılmasını sağlayacak ve bu profillerin SES, cinsiyet ve fen başarısının bilişsel alan boyutları değişkenleriyle ilişkisini ifade etmeye yardımcı olacaktır. Böylece söz konusu profillerin evrensel bulgularla karşılaştırılarak incelenmesi de mümkün hale gelecektir. Mevcut alanyazına olası katkılarını öngörerek yola çıktığımız bu çalışmada, Türkiye'den TIMSS 2019'a katılan sekizinci sınıf öğrencilerinin fen motivasyonel inançları ile ilgili ölçeklere verdikleri yanıtları örtük profil analizi ile belirlemeyi amaçladık. Bununla birlikte SES ve cinsiyet değişkenlerinin profil üyeliğini yordayıp yordamadığını da eş zamanlı olarak inceledik. Ayrıca SES ve cinsiyetin ortak değişken olarak dâhil edildiği profil üyelikleri durumunda öğrencilerin farklı fen bilişsel alanlarındaki performanslarında anlamlı farklılıkların olup olmadığının incelenmesi de amaçlanmıştır. Bu amaç doğrultusunda belirlenen alt araştırma soruları aşağıda verilmiştir.

S1: Öğrenciler arasında kaç farklı fen motivasyonel inanç profili ortaya çıkmaktadır?

S2: Öğrencilerin cinsiyeti ve sosyo-ekonomik durumları motivasyonel inanç profili üyeliklerini nasıl etkilemektedir?

S3: Öğrencilerin motivasyonel inanç profilleri bilme, uygulama ve akıl yürütme fen bilişsel alanlarındaki performansları ile nasıl ilişkilidir?

Araştırmanın veri seti, Uluslararası Eğitim Başarılarını Değerlendirme Kuruluşu (IEA) tarafından yönetilen TIMSS sekizinci sınıf öğrencilerine yönelik 2019 uygulamasından elde edilmiştir. Bu öğrenciler TIMSS 2019'a Türkiye'den katılarak bilimle ilgili motivasyonel inanç ölçekleri ve fen başarı testlerini yanıtladılar. Kullanılan değişkenlerin herhangi biri için puanı hesaplanmayan katılımcıların verileri silinerek 4048 öğrenci verisinden oluşan veri seti 3988 öğrenciye düşürülmüştür. Bu öğrencilerin 1982'si (%49,7) kız, 2006'sı (%50,3) erkektir.

Araştırma verileri, öğrencilerin içsel değerlerine (örneğin, okulda fen öğrenmeyi dört gözle bekliyorum) yönelik dokuz maddeden oluşan "Students Like Learning Science (SLLS)" ölçeği ve öğrencilerin benlik algısına ilişkin (örneğin, genellikle fen bilimlerinde başarılıyım) sekiz maddeden oluşan "Students Confident in Science (SCS)" ölçeği ile toplanmıştır. Ayrıca öğrencilerin fayda-değer yaklaşımlarına yönelik (örneğin, fen bilimleri öğrenmenin bana ödevlerimde yardımcı olacağını düşünüyorum) dokuz maddeden oluşan "Students Value Science (SVS)" ölçeğinden elde edilmiştir. Araştırma verisinin diğer bir bölümü de TIMSS'de fen başarısı için bilme, uygulama ve akıl yürütme olmak üzere üç bilişsel alanı ölçen başarı testinden elde edilmiştir. Testte bu bilişsel alanlarla ilgili soruların %35'i bilmeye, %35'i uygulamaya ve %30'u akıl yürütmeye ayrılmıştır.

Bu çalışmanın birincil analiz tekniği olarak ortak değişkenli örtük profil analizi (Latent Profile Analysis-LPA) kullanılmıştır. Çalışmada istatistiksel tahminlerin genellenebilirliğini artıracağı için TIMSS veri setindeki motivasyonel inanç değişkenleriyle birlikte “Toplam Öğrenci Ağırlıkları (Total Student Weight)”ler kullanılmıştır (Gonzalez, 2012). Veriye uygun model kararının ardından SLLC, SCS ve SVS değişkenlerinin farklı profillerdeki ortalama puanlarını yorumlanarak profil isimleri belirlenmiştir. Ayrıca modele "cinsiyet" ve "SES" değişkenleri ortak değişken olarak eklenmiştir. Son olarak, Asparouhov ve Muthén'in manuel BCH yaklaşımı (2014) kullanılarak öğrencilerin fen bilimleri bilişsel alanlarındaki performansının farklı profiller arasında istatistiksel olarak farklılaşıp farklılaşmadığı belirlenmiştir. Profil ortalamaları arasındaki farkları belirlemek için Z testi kullanılmış ve etki büyüklüğü Cohen’in d testi kullanılarak önerilen aralıkta hesaplanmıştır (Cohen, 1988). Tüm analizler Mplus (Muthen & Muthen, 1998-2017) ile gerçekleştirilmiştir.

Örtük profil analizi sonuçlarına göre, dört farklı profil ortaya çıkmıştır: "düşük motivasyon", "orta motivasyon", "yüksek motivasyon" ve "çok yüksek özgüvenli yüksek motivasyon". Erkek öğrencilerin, kız öğrencilere kıyasla "yüksek motivasyon" ve "çok yüksek özgüvenli yüksek motivasyon" profillerine atanma olasılıklarının daha az olduğu görülmüştür. Öte yandan, yüksek sosyo-ekonomik duruma sahip öğrencilerin ise, yüksek motivasyon profillerinde yer alma olasılığı daha yüksek bulunmuştur. Farklı motivasyon profillerindeki öğrencilerin başarı puanları ortalamaları arasındaki farklar incelendiğinde ise, düşük ve orta motivasyon profilleri arasındaki karşılaştırmalar hariç tüm ikili karşılaştırmalarda (tüm bilişsel alanlarda) istatistiksel olarak anlamlı farklar bulunmuştur.

Bu araştırmadan elde edilen bulgular, öğrencilerin fen motivasyonlarının artırılması için bütüncül bir yaklaşım benimsenmesi gerektiğini, bu süreçte öğrencilerin cinsiyet ve sosyo-ekonomik durumlarının dikkate alınmasının önemini vurgulamaktadır. Öğrencilerin farklı fen bilişsel alanlarındaki başarılarını artırmak için motivasyonel inançlarının desteklenmesi gerektiği sonucuna varılmıştır. Cinsiyet ve ses konusuna gelindiğinde ise bu çalışmanın sonuçları, erkeklerin fene yönelik motivasyonlarının daha yüksek olduğu yönündeki cinsiyet klişesini sorgulamaktadır. Farklı kültürlerde yapılan diğer çalışmaların sonuçlarıyla birlikte değerlendirildiğinde (örn. Liou vd., 2022), kültürün, beklenti-değer teorisi bağlamında fene yönelik motivasyonda varsayıldığı üzere doğuştan gelen özelliklerden daha etkili olduğu sonucuna varılabilir (Eccles ve Wigfield, 2020). Çalışmanın sonuçları, geleneksel toplumcu ve bireyci kültürlerin bir arada var olduğu bir kültürde öğrencilerin SES ve cinsiyet özelliklerinin etkilerini göz önünde bulundurmanın önemini vurgulamakta ve özellikle yüksek motivasyon profillerinde bu etkinin daha belirgin olduğunu ortaya koymaktadır.