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Pre-service teachers' and primary students' motivations and beliefs towards science

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ABSTRACT

In a fast-paced evolved modern world, scientific literacy (SL) is essential for an individual to interact and make decisions about science-related issues. A scientifically literate person should have not only scientific knowledge, but also motivations and beliefs toward science. The purpose of current research is the examination and comparison of pre-service teachers' and primary school students' motivations and beliefs towards science. There were 787 participants comprising the research sample. A three-factor structure was verified through statistical techniques such as exploratory factor analysis and confirmatory factor analysis. Moreover, the reliability coefficient is considered acceptable. According to descriptive analyses and statistical significance tests, both groups show medium to quite positive perceptions toward the value of science and science self-efficacy. Additionally, there is no statistically significant difference in both groups' performances regarding these categories. Regarding personal epistemology, students achieve a statistically significantly better performance than the teachers. However, both groups' scores were assessed as moderate to low. Suggestions for further research about primary school students' and teachers' SL motivations and beliefs are presented.

Keywords: scientific literacy, motivation and beliefs, primary students, pre-service teachers

INTRODUCTION

The development of scientific breakthroughs and scientific knowledge is accompanied by the necessity of decision-making on complicated science-related issues (Glynn et al., 2011). The effective participation of people in the decision-making process of modern society in which science and technology hold a central position, requires, regardless of whether they aspire to a professional career in a scientific field, that they are scientifically literate (Bybee, 2016). The negative attitude of many people to contemporary social-scientific issues (e.g., pandemic, climate change, and nuclear energy) but also the expansion of pseudoscientific theories may be the trigger to intensify the effort to achieve scientific literacy (SL) (Valladares, 2021).

SL is consistently a principal aim of science education (Fortus et al., 2022; Lederman & Bartels, 2018; National Academies of Sciences, Engineering, and Medicine [NASEM], 2016; National Research Council [NRC], 1996). The term SL remains vague due to its diverse interpretations under various visions (Ke et al., 2021). Visions range from acquiring scientific knowledge through the scientific practices used in science disciplines to science learning and using scientific knowledge toward everyday socio-scientific issues (SSI) decision-making (Roberts, 2007). Recently, a new vision has been proposed, which encourages individual and social transformation through science learning, activism and democratic involving in SSI (Sjöström et al., 2017). SL integral components, as a construct of motivation and beliefs towards science, are attitudes toward science (OECD, 2016).

Different motivational constructs influence students' engagement with science knowledge and learning (Daher et al., 2021). On the other hand, individuals' epistemic beliefs affect them to deal and critical evaluate the challenges and vast amount scientific information of the modern world (Guo et al., 2022). In fact, previous research has revealed that there is a significant relationship between students' motivation and their epistemological beliefs towards science (Guo et al., 2022; Sahin et al., 2023). Science education is crucial for cultivating valuable scientific knowledge, as well as fostering positive attitudes towards science (Jones et al., 2022). Primary teachers can shape students SL skills and attitudes toward science (Tsoumanis et al., 2024). Thus, it is essential to understand the attitudes and beliefs of undergraduate students towards science to customize teaching methods that encourage

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participation and improve SL skills across all students (Strzalkowski & Sobhanzadeh, 2023).

In this context, the present research endeavors compare the motivations and beliefs of both students and pre-service teachers (PSTs) concerning science, with the aim of furnishing valuable insights and enriching existing relevant literature.

Science Motivation & Beliefs

According to OECD (2017, 2019), SL is the individual's capacity to interact with concerns related to science and its concepts, as a thinking citizen. The goal of achieving SL requires that citizens in modern societies understand the connections and the utilization of scientific knowledge in a multitude of personal and social issues (Fortus et al., 2022). Therefore, scientifically literate students should have not only the knowledge but also the attitudes, motivation, and beliefs necessary so that, as future adults, they can respond to personal, social, and global issues related to science (Fives et al., 2014). Cognitive abilities and attitudes towards science are important assets for adolescents to be able to thrive in society (Jones et al., 2022).

Students' attitudes toward science start to form during their exposure to science education in primary school (Ecevit & Kingir, 2022). Numerous studies have found a positive association between students' epistemological beliefs, motivation constructs and interest about science (Schiefer et al., 2020). Thus, primary teachers' roles are crucial in inculcating students with SL skills (Ecevit & Kingir, 2022; Stylos et al., 2023). Fives et al., (2014) consider that the motivations and beliefs that a person must develop and perceive to be scientifically literate are the value of science (subjective task-value), self-efficacy and personal epistemology.

Science learning motivation is often defined as "an internal state that arouses, directs, and sustains science-learning behaviors" (Glynn et al., 2011, p. 2). Enhancing science motivation significantly contributes to both learning science and the promotion of academic success (Schumm & Bogner, 2016). It has become a major goal of education, providing the promotion of SL among tomorrow's citizens (Van Vo & Csapó, 2022). Students' motivation is affected by diverse factors (You et al., 2018). Some arise from individual characteristics, and others emerge interactions in families, school, and society (Jones et al., 2022; Van Vo & Csapó, 2022). Teachers take on a key role in the enhancement of the level of students' motivation and in maintaining students' interest for science (Aktan, 2019; Fitzgerald et al., 2013).

Value of Science (Subjective Task Value)

According to the expectation-value theory (EVT), individuals' motivation depends on their anticipation of success combined with the task value that they attribute to a particular task or objective (Eccles & Wigfield, 2002). EVT consists of an efficient structure about young peoples' understanding of motivation in science (Burns et al., 2022). Subjective task value refers to the value individual attach to their academic work and consists of four distinct types: attainment value, intrinsic value, utility value and cost (Brown et al., 2015; Eccles & Wigfield, 2002; Shin et al., 2019; Tsai et al., 2023). Moreover, is a construct that could impact students' learning of science (Daher et al., 2021). Understanding the usefulness of science can increase students' motivation to engage in scientific topics (Shin et al., 2019). The appreciation of science's value, both on a personal and social level, is an important trait of scientifically literate individuals and therefore an important factor in achieving SL (Fives et al., 2014).

Self-Efficacy

Self-efficacy refers to an individual's confidence in his capacity to accomplish a set of tasks to achieve desired outcomes (Bandura, 1997). A consistent and causal correlation prevails among self-efficacy and academic performance (Høigaard et al., 2015; Honicke & Broadbent, 2016; McBride et al., 2020; Schneider & Preckel, 2017). This association determines a student's judgment of their capability to achieve academic objectives (Honicke & Broadbent, 2016), influences student participation in the educational process and future career choices (Webb-Williams, 2018), and can predict their performance in science (Saroughi & Cheema, 2023). Science self-efficacy refers to an individual's beliefs about their capacity to achieve specific goals, which require scientific knowledge and skills (Mason et al., 2013; McBride et al., 2020; OECD, 2016). Hence, is considered as a crucial element influencing in better science learning (Karaismailoglu et al. 2024). There is a direct correlation among science self-efficacy with students' SL achievement and science performance (Dorfman & Fortus, 2019; Hushman & Marley, 2015; Kutur, 2021; Lin et al., 2013; McBride et al., 2020).

Teachers' self-efficacy relates to their confidence that they can effectively deal with tasks, duties and problems related to their occupational role (Caprara et al., 2006). Furthermore, it is directly linked to learning achievements, motivation, and to the self-efficacy of the students themselves (Caprara et al., 2006; Oppermann & Lazarides, 2021; Tschannen-Moran & Hoy, 2007). However, primary teachers' apprehensions and unfavorable attitudes toward science will, in turn, their self-efficacy for learning and teaching science (Stylos et al., 2023).

Personal Epistemology

Personal epistemology refers to an individual's beliefs of knowledge and knowing (Hofer, 2001). It relates to what people think knowledge is, as well as how they interpret, evaluate, and justify knowledge and finally how they develop knowledge (Hofer, 2001; Hofer & Bendixen, 2012). According to Hofer (2000), it consists of distinct but interrelated dimensions grouped into two sections: the nature of knowledge and the nature or process of knowing. These consist of various components. The certainty and the simplicity of knowledge are related to the nature of knowledge. The source and the justification of knowledge refers to the nature of knowing (Hofer, 2000). Personal epistemology is a crucial component in the learning process of students that may be developed in early years (Alpaslan, 2017) and it is critical about students' academic motivation, cognition, and performance (Bråten et al., 2009). Hence, and as individuals' beliefs regarding knowledge influence their conduct and options toward a majority of everyday conditions connected with learning and decision-making, teachers' work has a special role (Dorota, 2020). Teachers' epistemological beliefs

Table 1. SLA-MB components' a-Cronbach and % of total variance for each group

Factors	n (items)	Students		Teachers	
		Cronbach's alpha	Total variance (%)	Cronbach's alpha	Total variance (%)
Personal epistemology	10	.698	19.46	.841	27.04
Self-efficacy	8	.767	12.14	.839	17.69
Value of science	4	.686	5.27	.861	6.32

influence their pedagogical practices and thus influence students' learning process (Hofer & Bendixen, 2012).

Present Study

This study's purpose is to examine and compare the motivations and beliefs about science among primary school students and pre-service primary teachers. The study's object was two-fold:

1. To explore students' and PSTs' motivations and beliefs about science?
2. To investigate what are the meaningful differences, if any, between students' and PSTs' motivations and beliefs about science?

METHODOLOGY

Participants

The study was conducted with 6th grade primary school students (aged 11-12) and PSTs. The sample of 787 participants clustered into two groups. The first group comprised 425 6th grade students from nineteen schools of different geographical zones of Ioannina, Greece. The second group comprised 362 undergraduate PSTs of department of primary education, University of Ioannina, Greece. Participation was voluntary and students participated with parental consent.

Instruments

The research instrument utilized for this research was SLA-MB. SLA-MB was created by Fives et al. (2014) as a part of SLA (scientific literacy assessment). SLA-MB consists of 25 items across a 5-Likert scale and is divided into three categories: value of science, self-efficacy, and personal epistemology. (Fives et al., 2014). According to Fives et al. (2014), to assess SL motivations and beliefs (SLA-MB), existing assessment measures were reviewed and selected based on their conceptual foundation and their consonance that value of science, self-efficacy, and personal epistemology are considered salient motivations and beliefs of SL. The translation of SLA-MB in Greek is carried out as part of SLA (Tsoumanis et al., 2023).

Data Collection

The questionnaire was completed online by PSTs. Students completed the questionnaire in the classroom under the supervising of their teachers. The time required to complete the questionnaire was approximately one hour. The absence of authors is justified by the special health conditions due to the COVID-19 pandemic. All questionnaires were collected, evaluated and the final database was created.

Statistical Analysis

SLA-MB is validated through an exploratory factor analysis (EFA). Internal consistency reliability was tested with Cronbach's alpha coefficient (Field, 2018). Consistency testing was performed for all SLA-MB factors as a whole and for each factor separately. A descriptive analysis of the response to SLA-MB Likert scale questions revealed participants' performance. Specific statistical indicators were calculated, and suitable charts and tables were formed. Finally, hypotheses tests were performed to investigate the differences of mean score and responses between students and PSTs.

RESULTS

Exploratory Factor Analysis

Factors were determined through a principal component analysis and based on several criteria including structure coefficients equal to 0.300, scree plot analysis and eigenvalues surpassing one (Benishek & Lopez, 2001; Pett et al., 2003; Stevens, 1992). In the present study, we deleted the questions that had been removed (Items: 27, 32, 44) for each sample in the previous analyzes (Stylos et al., 2023b; Tsoumanis et al., 2024) as low loadings, to make the comparison between the two groups of the sample on the same questions of SLA-MB.

Kaiser-Meyer-Olkin (KMO) was .834 for the students' sample and .880 for PSTs. Values greater than .700 for KMO measure of sample adequacy are acceptable (Field, 2018). The Barlett's test of sphericity was statistically significant for both students (χ^2[231]=1,738.779, $p<.05$), and PSTs (χ^2 [231]=3,165.627, $p<.05$), confirming the suitability of EFA and supporting the factorability of the correlation matrices (Bartlett, 1950; Kaiser, 1970).

EFA demonstrates three factors, which verified through eigenvalues above 1.00 and scree plot analysis. Regarding the students' sample, the first three factors explain 37.32% of the total variance of the sample. **Table 1** demonstrates the variances that three factors explain.

Reliability & Internal Consistency Testing of SLA-D1 & SLA-MB

The internal consistency of SLA-MB was investigated by the a-Cronbach reliability test. Regarding students the coefficient of the overall SLA-MB questionnaire was a=.628. and for PSTs was a=.861. The category "value of science" consisted of four factors, "self-efficacy" consisted of eight factors and "personal epistemology" consisted of 10 factors. The reliability coefficient for each category is shown in **Table 1**.

Table 2. Descriptive statistics of SLA-MB components (%)

Components	Students			Teachers		
	Mean	Standard error	Standard deviation	Mean	Standard error	Standard deviation
Value of science	76.14	.93	19.16	76.05	.81	15.50
Self-efficacy	69.33	.63	12.89	70.47	.73	13.81
Personal epistemology	59.27	.78	16.00	51.98	.71	13.55

Table 3. Score in "value of science" component

Item	Students		Teachers		Included	
	Mean	SD	Mean	SD	Mean	SD
28	4.02	1.23	4.03	.874	4.02	1.08
29	3.99	1.28	3.96	.974	3.97	1.15
30	3.65	1.34	3.80	.986	3.72	1.19
31	3.57	1.43	3.43	.931	3.50	1.23

Note. SD: Standard deviation

Table 4. Score in "self-efficacy" component

Item	Students		Teachers		Included	
	Mean	SD	Mean	SD	Mean	SD
33	3.59	.994	3.59	.899	3.59	.951
34	3.47	1.19	3.59	.965	3.52	1.09
35	3.26	1.12	3.28	.929	3.27	1.03
36	3.23	1.23	3.65	.982	3.43	1.13
37	3.71	1.08	3.46	.905	3.59	1.01
38	3.75	1.29	3.36	1.05	3.57	1.20
39	3.45	1.09	3.91	.849	3.66	1.01
40	3.27	1.19	3.34	1.14	3.30	1.17

Note. SD: Standard deviation

Table 5. Score in "personal epistemology " component

Item	Students		Teachers		Included	
	Mean	SD	Mean	SD	Mean	SD
41	2.84	1.41	3.02	1.08	2.92	1.27
42	2.75	1.38	2.71	1.12	2.73	1.26
43	3.04	1.42	2.87	1.03	2.96	1.26
44	2.42	1.34	3.45	1.08	2.89	1.33
45	3.09	1.39	2.76	.973	2.94	1.23
46	3.28	1.47	1.61	.956	2.51	1.51
47	3.19	1.29	2.67	1.01	2.95	1.20
48	3.27	1.44	2.06	1.04	2.71	1.41
49	3.01	1.45	2.32	1.13	2.69	1.36
50	2.74	1.45	2.53	1.12	2.65	1.31
51	2.84	1.41	3.02	1.08	2.92	1.27

Note. SD: Standard deviation

Descriptive Analyses & Hypothesis Tests

Mean score of SLA-MB components

Three new variables were created to calculate the score for each item of SLA-MB. The score was derived from the sum of the answers given in each category. Greater means "indicates better performance, stronger value, self-efficacy, and more sophisticated beliefs about science" (Fives et al., 2014, p. 569). The descriptive statistics are presented in **Table 2**.

Score of each question of SLA-MB components

Subsequently, the percentage of each answer given to the questions of SLA-MB components are presented in **Table 3**, **Table 4**, and **Table 5**. As SLA-MB is rated on a scale of one-five, a minimum score of one and a maximum of five are considered.

Differences in score of SLA-MB components

The score of SLA-MB components for both groups is shown in **Table 2**. Analyzing the descriptive results is observed that the highest score for the two groups is in the category "value of science", which is characterized as quite good. In this particular category both groups achieve almost the same score. The score of the category "self-efficacy" can be classified as satisfactory for both groups. PSTs score slightly higher. Finally, the lowest score is observed in the category "personal epistemology". There it seems that students achieve higher scores than teachers.

Nonparametric tests were then carried out to determine whether there were statistically significant differences in scores across the groups.

According to the **Table 6** there is no statistically significant difference between the scores of the two groups in categories "value of science" (U=73.455, z=-1.097, p=.273, r=-0.03) and "self-efficacy" (U=79.287, z=.745, p=.456, r=0.02) confirming the descriptive analysis. In contrast, it seems that the students perform better than the teachers in the category "personal epistemology" as a statistically significant difference is observed.

DISCUSSION

Students seem to have medium to high scores in the category "value of science". These results are consistent with previous studies (Tsoumanis et al., 2023). Particularly, students' attitudes about utility value of science can characterized as highly positive. Students' attitudes toward attainment of the value of science are also quite positive. Furthermore, students show positive attitudes but to a lesser extent in the intrinsic value of science. An enhanced perception in task values (i.e., utility, attainment value and intrinsic value) positively related to enhancing student motivation, performance, and academic achievement (Dietrich et al., 2015; Hulleman et al., 2017; Li et al., 2021; Shin et al., 2019). Correspondingly are PSTs' results in this component. Teachers are in a unique position to influence students' task value dimensions beliefs (Kafkas, 2016). Teacher-student relationships (Burns et al., 2019, 2022; Han et al., 2019), teachers' frequency and clarity of statements about task value (Kafkas, 2016) and interventions in classroom (Canning et al., 2019; Hecht et al., 2018) are certain factors that have impact and can shape students' task value beliefs.

Regarding self-efficacy in science, the results of current study showed that both students and PSTs' scores were fairly good. Although, teachers' performance was slightly better the difference was not statistically significant. The results for teachers are like previous studies (Ecevit & Kingir, 2022; Koutsianou & Emvalotis, 2019; Stylos et al., 2023a). Students

Table 6. Differences in SLA-MB components between groups

Components	Students (M-SD) (%)		Teachers (M-SD) (%)		U	z	p
Value of science	76.14	19.16	76.05	15.50	73.455	-1.097	.273
Self-efficacy	69.33	12.89	70.47	13.81	79.287	.745	.456
Personal epistemology	59.27	16.00	51.98	13.55	54.002	-7.219	.000

seem to achieve lower scores compared to students from similar surveys (Fausan & Pujiastuti, 2017; Fives et al., 2014; Tsoumanis et al., 2024). The results about teachers, maybe reveal that the sample believe that have a strong science background. Moreover, PSTs may feel confident about their own abilities in teaching science (Stylos et al., 2023). In this case, it is possible to overestimate their efficacy beliefs in science and may be risk of setting up ambitious and demanding goals (Koutsianou & Emvalotis, 2019). Furthermore, the good self-efficacy level may be affected by the teachers' high school course specialization (Stylos et al., 2023a).

According to the results of personal epistemology students scored higher than teachers' and the difference is statistically significant. Nevertheless, both scores were considered moderate to low. Compared to most equivalent studies (Diana et al., 2015; Fives et al., 2014; Rohana et al., 2020; Wilson et al., 2018) students' average score was significantly lower. Students' views over the source and certainty of knowledge were sophisticated (means were close to the midpoint) (Alpaslan, 2017; Conley et al., 2004). Regarding certainty, they seem to lean toward the view that knowledge is not fixed or absolute (Conley et al., 2004; Schiefer et al., 2020). The conflicting opinions of scientists and the students' experiences in science classrooms could allow a student to develop the belief that experts are not omniscient (Barger et al., 2018). Teachers appear to have naïve beliefs about science (Korom et al., 2023). In comparison to students, we could consider them similar but naiver regarding the source and certainty of knowledge. This is perhaps due to the fact that certainty of knowledge is an issue that teachers do not think much about and associate it with academic rather than professional issues (Erixon & Hansson, 2022). Furthermore, teachers may believe that knowledge originates outside the self, as expert knowledge (Erixon & Hansson, 2022).

CONCLUSIONS

The outcomes indicate that both students' and PSTs' motivation and beliefs towards science ranged from low to fairly good level, depending on the category of SLA-MB.

Regarding the category "value of science" both groups seem to have the same performance, which is also the best among the three categories. Thus, both seem to and have pretty positive perceptions and attitudes toward the value of science. This finding may reflect the assumption that children's attitudes towards science are developed starting from their experiences in elementary education, shaped by educational institutions (Jones et al., 2022). On the other hand, it is not obvious that these attitudes enhanced. Teachers' results probably show that they are maintained as students' progress through the educational levels.

Self-efficacy is one of the central components that affects and is linked with levels of motivation, persistence, involvement, and academic performance (Dermitzaki et al., 2013; Honicke & Broadbent, 2016). Demographic characteristics and other factors such as age, gender (Daher et al., 2021; Dorfman & Fortus, 2019; Schumm & Bogner, 2016; Van Vo & Csapó, 2022; Webb-Williams, 2018), the family, peers, school culture (Dorfman & Fortus, 2019; Zhang et al., 2024) and environmental and sociocultural contexts (Usher et al., 2019), may affect students' self-efficacy. However, teachers play a major role in shaping students' self-efficacy (Dorfman & Fortus, 2019). Hence, both groups positive performance may be a catalyst/predictor of students' engagement with science, leading to an increase in their levels of SL (Karaismailoglu et al. 2024). Although Greek PSTs seem to be relatively confident in teaching and engaging in science, it is necessary, for them to have the chance during their studies to enhance their self-efficacy level, via teacher education programs (Stylos et al., 2023a).

Additionally, teachers' low performance in personal epistemology is raise concern in the light of that the views about the nature of knowledge and knowing are important elements in the learning process of students (Alpaslan, 2017), in terms of instructional and assessment methods and readying students for adulthood (Erixon & Hansson, 2022).

Limitations & Future Research

Several study limitations warrant acknowledgment, and there are also potential avenues for future research that are noteworthy. One limitation to the study is the that the sample was selected by the method of convenient sampling and from a single area of Greece. As a result, the sample does not represent a wide range of primary school students and PSTs. Moreover, future research could aim to examine the motivation and beliefs level among students across all levels of education. Furthermore, the influence of factors such as age, gender, socio-economic status, and cultural capital could also be considered. Finally, a longitudinal survey will allow researchers to study thoroughly the motivation and beliefs toward science from the same sample of groups.

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

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

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