OPEN ACCESS

Research Paper

DINAMIKA Jurnal Ilmiah Pendidikan Dasar, 2022, 14(2)
ISSN:2655-870X (online)
https://doi.org/10.30595/Dinamika/v14i2.13303

Southeast Asian Students' Perspective in Science and Science Education

Mariam Othman[1], Nelson Cyril [2*], Dominador Dizon Mangao[3], Khar Thoe Ng [4], Deva Nanthini Sinniah[5] Murugan Rajoo[6]

[1,3,4,6] Research and Development Division SEAMEO RECSAM Penang, MALAYSIA
[2*] Phillipine Normal University, PHILLIPINES
[5] Universiti Pendidikan Sultan Idris, Tanjong Malim, MALAYSIA
[6]Research and Development Division SEAMEO RECSAM Penang, MALAYSIA

Received 10 November 2018 ▪ Revised 5 February 2019 ▪ Accepted 4 March 2019

ABSTRACT

The study describes the attitudes and beliefs towards science and science education of Year 9 and 10 Southeast Asian students including gender and year level differences based on the seven categories. This study involved Year 9 and 10 students from seven SEAMEO countries. Out of 5,375 samples selected, 2,158 were boys and 3,217 were girls. There were seven categories in the survey instrument that was administered, including students' perceptions about: (1) science; (2) science outside school; (3) science topics; (4) scientist vocation; (5) self-efficacy in science; (6) teaching and learning science; as well as (7) future participation in science. The analyses showed that generally students had positive attitudes on categories such as: science, science outside school, teaching and learning science, scientist vocation, science topics and future participation in science. However, in general, the students in this region had slightly low self-efficacy in science in which included items such as science as a difficult subject and science classes are boring. The results also showed that Year 9 and boys acted more positively than Year 10 and girls in the attitudes and beliefs towards science. Further research and recommendations are explored. The findings would be used as a tool to revise the national science curriculum of the participating countries in terms of content standards and inform teachers of how teaching and learning practices can be aligned with students' attitudes and perceptions to obtain better learning outcomes. The research findings could also be used as a springboard for further research exploring deeper the variables affecting students' success in science and providing intervention for teachers' training curriculum and continuing professional development in terms of technological pedagogical content knowledge (TPACK) that would increase the interest of students in learning and exploring science.

Keywords: Attitudes, Beliefs, Science, STEM, Teaching and learning science, SEAMEO

INTRODUCTION

In the era of Industrial Revolution (IR) 4.0, science is one of the subjects in Science, Technology, Engineering and Mathematics (STEM) education that can improve our living skills as well our environment. For any nation to move forward in this competitive borderless world, a strong foundation in science and technology is pertinent. However, many studies in large scale assessments have shown that students' interest in science is decreasing as they move to higher grades [37][38]. This is a major concern that needs to be addressed by policy makers and educators.

Thus, many countries including South East Asian Ministry of Education Organisation (SEAMEO) countries have inculcated the STEM education in the curriculum to circumvent the lack of interest among students in science. In recognising the significance of STEM Education, SEAMEO RECSAM has produced concepts of STEM education in SEAMEO

✉ nelson@recsam.edu.my **(*Correspondence)**

Basic Education Common Core Regional Learning Standards (CCRLS) in Mathematics and Science [21]. Nevertheless, there should be a study to ascertain the students in SEAMEO countries' attitudes and beliefs in science.

Research Objectives

The objectives of this study are as follows:

1. To ascertain South East Asian students' perspective towards science and science education of the Year 9 and Year 10 students based on the following seven categories:
    a. science;
    b. science outside school;
    c. teaching and learning science;
    d. self-efficacy in science;
    e. how scientists work;
    f. interest in science topics; and
    g. future participation in science.

2. To identify the differences in the South East Asian students perspective in science and science education according to the seven categories among the Year 9 and Year 10 students by gender and year levels.

Research Questions

Based on the objectives above, the research questions are as follows:

1. What are the attitudes and beliefs towards science and science education of the Year 9 and Year 10 students from South East Asian countries based on their perceptions in the following seven categories:
    a. What are the perceptions of students about science?
    b. What are the perceptions of students about science outside school?
    c. What are the perceptions of students about teaching and learning science?
    d. What are the perceptions of students about self-efficacy in science?
    e. What are the perceptions of students about how scientists work?
    f. What are the perceptions of students about interest in science topics?
    g. What are the perceptions of students about future participation in science

2. Are there differences in the attitudes and beliefs towards science and science education according to the seven categories among the Year 9 and Year 10 students from South East Asian countries by gender and year levels?

Literature Review

Over the past few decades, there has been an increase in studies on the motivation aspect of learning as well as the types of classroom learning environment and science related activities to enhance the interest to study school science among students in science education [27].

Operational Definitions of Attitude, Belief and Perception

Attitudes are more often operationally defined as responses to several objects along an evaluative dimension that is bipolar [12]. 'Attitudes' and 'perceptions' were quite frequently being used interchangeably to refer to the same thing especially when the simple attitude scale was used to collect data. Of course, these terms were also meant to be different by some authors.

Attitudes were defined to have 3 components including an affect (a feeling), behaviour (actions) and cognition (a belief or thought) involving a complex combination of things namely behaviours, beliefs, motivations, personality and values [28]. The tri-component of attitudes provide beliefs or cognitions that are internal as well as thinking about objects and people with definition of how situations are seen as well as how we behave toward an object or the situation.

'Attitude' is defined as how we act or react. The action of a person or performance of thinking is dependent on his/her attitude. This action is just a show-off of belief and perception. 'Belief' is the root foundation of how we think, including the values we possess. 'Perception' is the sieve of any input anchored on one's belief. It is the point of view or thinking method. In brief, the action or reaction of oneself is directly influenced by his/her beliefs, values and way of thinking [35].

The words 'attitudes' and 'perceptions' are used reciprocally to depict the attitudes and beliefs toward science as well as science education of Year 9 and 10 students from SEAMEO countries based on their interpretive responses towards the seven categories of attitude questionnaire items[34].

Literature revealed that there were two main challenges to pursue research on 'attitudes towards science' [27]. The first challenge is that it contains many sub-constructs contributing to varying proportions towards the attitudes towards science of an individual, hence it does not contain a single unitary construct. Hence, many studies were conducted incorporating a diverse range of components that measure attitudes to science. These include the achievement in science, the anxiety toward science and fear of failure on course, attitudes of peers or friends or parents towards science, enjoyment of science, motivation towards science, the nature of learning environment in classroom, the perception of the science teacher, self-esteem of student towards science as well as the value of science.

Secondly, the challenge to assess the importance and significance of attitudes is that they are fundamentally a measure of the expressed feelings and preferences of one person towards an object but these measurements will not be related to the behaviours that are actually exhibited by a pupil. It was pointed out that the predicted impact of a specific behaviour may have modified the behaviour such that it is inconsistent with the attitude held[6]. Another possibility is that motivation to behave in an alternative way could be stronger than the motivation that is associated with the indicated attitude or attitudes apart than the ones that are considered may be strongly held. The study involving 1564 of 16-year old or Grade 10 students in the US revealed that 72% students thought science to be valuable and 73% of students showed indication that science is important. However, about 40% indicated that science classes were found to be boring [11].

Factors Affecting Attitudes towards Science and Achievement

Quite a number of factors were identified to have affected attitudes towards science generally and gender is the most significant [13]. The research studies that were conducted between 1970 and 1991 revealed that boys have a more positive attitude to school science consistently than girls, though this effect is stronger in physics than in biology [4]. In fact boys who took mainly 'masculine' subjects described themselves as high on traits of competence and aggression. They were found to be likely motivated extrinsically for a highly paid job with recognition and status. Boys were also generally likely to choose careers that are sex-stereotyped. Hence, this attitude reflected there was a greater need to build and strengthen the gender identity of boys than that of girls.

Much of the present research showed minimal achievement differences between boys as well as girls in mathematics and science [8]. The study on 'Trends in gender gaps: using 20 years of evidence from TIMSS' revealed that among the 15 out of 39 countries participating in TIMSS 2019, a significant gender gap was shown that favoured girls' science achievement [22]. Boys were averagely better than girls in 6 countries and there was gender equity in 18 countries.

In addition, much of the literature revealed that a key issue for consideration of research was the relationship between attitude and achievement. Attitude and ability scores could be expected to correlate moderately in the current position [32]. The measures used in the TIMSS study were found to have a consistent relationship between attitude and achievement [3]. In a meta-analysis research, it was suggested that only a moderate correlation was found between attitude towards science and achievement, although this correlation is stronger for high and low ability girls, indicating that for these groups, 'doing well' in science is closely linked with 'liking science' [40]. Yet, in the longitudinal study it was argued that a strong relationship was seen between the 3 affective variables (namely attitude toward science, an individual's self-concept on his/her own ability and motivation to achieve) with their achievement in science[26]. A study also revealed that students were motivated intrinsically for science learning when they wanted to do so due to what they would be able to achieve after they had mastered the new concepts [9]. They found it enjoyable in science learning and working on science problems

MATERIAL AND METHODS

The Design of Research Study

This study only examines the sample extracted from a population at one particular point of time. Mixed-method research involving cross-sectional survey, case studies and interviews with mixed-mode of quantitative and qualitative data analysis was implemented [23]. The findings are presented in a descriptive manner and not involving the manipulation of variables. This means that only illustrative details about what is happening in a given school year within the current student population was provided [18]. In this study, various attributes (i.e. gender and year levels) were examined simultaneously with only established

attributes in a given population being described.

The Instrument for Research Activities

The Australian STEM Futures Centre in the Faculty of Education, University of Technology Sydney was tasked to design the instrument with 57 items. The survey items obtained were adapted from various established questionnaires but mainly from a validated attitude scale [19].

The 'Attitudes and Beliefs towards Science' survey consisted of numerous items in the form of Likert scales with four choices, including: Strongly agree (SA), Agree (A), Disagree (D) and Strongly disagree (SD). There were 7 categories as well as correlated items with numbers in brackets: (i) How scientists work (8 items); (ii) interest in science topics (14 items); (iii) relevance of science (11 items); (iv) science outside school (6 items); (v) self-efficacy in science (4 items); (vi) teaching and learning science (11 items); as well as (vii) future participation in science (3 items).

Validation of Language Translation and Content

The original questionnaire in English language was translated into the language used in the participating countries by the research coordinator in the Ministry of Education of the participating countries including Brunei Darussalam, Indonesia, Malaysia, Myanmar, Thailand and Vietnam. Translation activity was not included in the Philippines which maintained that English version as the preferred language of instruction. Content validation was checked by the experts of the participating countries on the translated items. The translated surveys were then reverted to Australian University Technology Sydney. The university created web links for each participating country using a digital tool namely Survey Monkey. Reliability analysis with Cronbach Alpha value of 0.696 to 0.883 were seen in all survey items suggesting an acceptable instrument for this study [7].

The d value calculated in this study were to measure effect size as an indication of the normalized distinction between genders (boys and girls) as well as levels of study year (Grade 9 and 10). The authors suggested that d=0.2 is the value for 'small' effect size, 0.5 is the value for a 'medium' effect size and 0.8 represents a 'large effect' size [7].

The Participating Students and Sample Schools

Random selection was made across the schools in the 7 Southeast Asian participating countries by the research country coordinators of the respective country on the sample of Year 9 and 10 students with age groups between 14 to 16 years old. Table 1 showed the distribution of participants enrolled in the School Year of 2018.

Table 1. The Distribution of Participants

Country	Grade/Year Level				Total Valid Responses for Analysis		
	Grade 9		Grade 10				
	Boys	Girls	Boys	Girls	Boys	Girls	Total
Survey using local language							
Brunei Darussalam	173	210	146	208	320	419	739
Indonesia	243	344	171	242	414	586	1000
Malaysia	98	116	47	55	145	171	316
Myanmar	158	283	122	177	288	467	755
Thailand	129	169	116	253	245	423	668
Vietnam	237	289	185	289	422	578	1000
Survey using English version							
Philippines	155	288	168	282	324	573	897
Total	**1,193**	**1,699**	**955**	**1,506**	**2,158**	**3,217**	**5,375**

Administration of Survey Instruments

The questionnaire items were administered using Survey Monkey e-platforms for a total of 3 months. Different survey links that were created for each participating country were sent to the country research coordinator from Australian University Technology Sydney through the main researcher based in SEAMEO RECSAM. Subsequently, the research coordinator in each participating country sent the survey link to the principals and/or the science teachers of the selected Year 9 and 10 students of the respective school to participate in the e-survey study. During the actual study with administration of instruments, students were requested to respond to the e-survey during class time using their available tablets or laptops or the computers at their school's computer room.

The Analyses of Data

Since this is a descriptive study, quantitative data collected was analysed using SPSS Statistical Package to obtain only frequency, percentage, means and standard deviations. Reports of findings are made on the frequency, means and standard deviations (SD) for the items in each category. Frequencies were calculated for a set of statements with a 4-point Likert-scale. 'Means' that are greater than 2.5 are considered positive, means less than 2.5 are considered as negative and mean of 2.5 is considered neutral. The presentation of results included collapsing the percentages of responses on 'Strongly Agree and Agree'.

Data Analysis

The findings present the regional results of the seven categories of attitudes towards science and science education investigated in this study. The findings also include gender and year level differences by the seven participating countries.

Table 2 shows that the regional mean average value is 3.02 which indicates that Year 9 and Year 10 students from this region have a high positive attitude towards science and science education

Table 2. Regional Summary on the Seven Categories

Category	Average mean
What students think about Science	3.24
Science outside School	3.04
Teaching and learning science	3.14
Self-efficacy in science	2.52
How scientists work	2.94
Interest in science topics	3.09
Future participation in science	3.19
Mean Average	**3.02**

Findings on Gender Differences Regionally

Table 3 shows the summary of results of regional mean values of the seven categories according to gender. The results indicated that boys were slightly more positive towards science and science education than girls with the mean values 3.04 and 3.01 respectively. The boys showed more positivity than girls in five categories, namely: what students think about science (3.25), future participation in science (3.10), interest in science topics (3.08), how scientists work (2.93), and self-efficacy in science (2.77). However, the girls were more positive than boys in teaching and learning science (3.18) and science outside school (3.08).

Table 3 Regional Summary on the Means of Seven Categories between Genders

Category	Means	
	Boys (N = 2,158)	**Girls (N = 3,217)**
What Students Think about Science	3.25	3 .16
Science Outside School	3.05	3 .08
Teaching and Learning Science	3.08	3 .18
Self-efficacy in Science	2.77	2 .69
How Scientists Work	2.93	2 .88
Interest in Science Topics	3.08	2 .97
Future Participation in Science	3.10	3 .08
Regional Mean Average	**3.04**	**3 .01**

Table 4 (see Appendix A) indicated the summary of regional mean values, standard deviations, p values (at the $p<0.01$ [99%] confidence level). Table 4 also displayed the effect sizes (d) for items that showed a significant difference between the genders. The independent

samples t-test results in Table 4 showed there were some significant differences found between genders. These differences can be classified from small to medium effects[7].

Results demonstrated that Myanmar recorded the highest mean value with medium effect size (d=0.54) in the category of interest in learning science topic 'Nanotechnology'. In this category the boys seemed more interested in the topic than the girls. Similar cases were true with 'Topics in physics'. Nevertheless, the results also found that girls were found more interested in the topic 'Human biology' than the boys. In general boys seems to 'like science better than most other subjects at school' while girls perceived that science is difficult with the effect sizes were considered small

Findings on Year Level Differences Regionally

Table 5 showed the summary of regional mean values of the seven categories of the items that showed significant difference at $p<0.01$ confidence level between the year levels (N year 9 = 29000 and N year 10 = 2463

Table 5 Regional Summary on the Means on the Seven Categories between Year Levels

Category	Means	
	Year 9 (N= 2,900)	Year 10 (N= 2,463)
What Students Think about Science	3 .11	3.17
Science Outside School	3 .11	3.13
Teaching and Learning Science	3 .12	3.1
Self-efficacy in Science	2 .54	2.47
How Scientists Work	3 .01	2.93
Interest in Science Topics	3 .08	3.01
Future Participation in Science	3 .02	3.25
Regional Mean Average	**3 .00**	**3.01**

Results in Table 5 depicted that Year 9 and Year 10 students were positive towards science and science education with the average mean values of 3.00 and 3.01 respectively. It seemed that Year 10 students were slightly more positive than Year 9 in three categories, namely; what students think about science (3.17), and science outside school (3.13). However, Year 9 students were slightly more positive than Year 10 students in the categories of teaching and learning science (3.11), self-efficacy in science (2.54), how scientists work (3.01), and interest in science topics (3.08). As for the category future participation in science Table 6 (see in Appendix B) exhibited a detailed summary of regional mean values, standard deviations, p values (at the $p<0.01$ [99%] confidence level) that showed a significant difference between the year levels. According to independent samples t-test results in Table 6, there were some significant differences found between year levels from the participating countries in this study. Referring to Cohen et al. (2018), the differences between year levels may be classed as small to medium size effects. It seemed that both year levels perceived positively in future participation in science with nearly equal means which were 3.00 and 3.01 for Year 9 and Year 10 respectively.

RESULTS AND DISCUSSION

Summary of Findings on the Seven Categories

What Students Think about Science?

The regional group mean average value of 3.24 (see Table 2) endorsed the findings that the students in this study had positive attitudes toward science. They respect the fact that science is important to them as a human being (i.e. student and becoming an adult). This is aligned with TIMSS 2019 findings that the majority of 8th grade students (79%) liked or liked learning science. This conclusion is supported by a study conducted by the Institute of Electrical Engineers in the United Kingdom [36], which found that students aged 14-16 considered science and technology were "important" or "very important" in everyday life (87 percent), "useful" (68 percent), and "interesting" (53 percent), with no major differences between genders. Similarly, according to another study, 72 % students' considered science as valuable and 73% as important [11].

Science Outside School

The regional group means average value of 3.04 indicated that the students in this sample have generally optimistic attitudes, showing that they are interested in becoming involved in science outside of school hours. On average, across OECD countries, 23 percent enjoy watching science-related TV shows and 19 percent prefer visiting science-related websites [29]. Also, the majority of eighth-grade students use the internet for schoolwork; 69 percent collaborated on assignments with classmates; 56 percent accessed textbooks and course materials; and 53 percent accessed their assignments [37]. The author, commented that there is no connection between attitudes toward science and participation in extracurricular activities such as science clubs [41]. On the other hand, presented compelling evidence for the importance of science clubs [20]. The PISA 2015 results observed that 11 percent of boys and just 6 percent of girls in OECD countries regularly attend science related activities. 'The real experience of science at school does not appear to be associated with attitudes toward science as a worthwhile social enterprise and participation in extra-curricular science activities,' according to [5]. This supports the notion that science in the classroom and science outside of the classroom should be considered as radically different entities.

Teaching and Learning Science

Students in this group were enthusiastic about science teaching and learning, as shown by the regional category mean average value of 3.14. This result is in line with the findings that teacher-related factors were the most common explanation for liking or disliking the topic [16]. This is emphasised in other study that found the most significant factor influencing students' attitudes was the type of science instruction they received[11]. On the other hand, [41] found that the standard of school science instruction is a major determinant of student attitudes toward the subject. This study results are also aligned with TIMSS (2019) that stated 49% of Year 8 students reported high clarity of instruction as important when learning science.

Self-efficacy in Science

Based on the findings, 60 % of the students in this study find science to be a difficult topic, but 61% of these students stated they can pick it up quickly. Science is liked by 59 percent of students more than any other subjects in school, and just 22 percent find it boring. Another important findings from the literature found that 40% of 1564 Grade 10 US students (16-year-olds) reported that science was important to them [11].

How Scientists Work

The regional group mean average value of 2.94 indicated an optimistic view on how scientists function. Students in this study had a clear understanding of the purpose and method of science, as well as the importance of imagination in relation to how scientists work, according to the findings. However, many students continue to believe that all scientists follow the same step-by-step scientific method (71%).

Interest in Science Topics

The regional group mean average value of 3.09 confirmed the findings that students in this study had a strong interest in studying science topics. In general, 91% of students were very interested in learning how scientists design experiments and 91% were interested in learning how scientists describe experimental findings.

The TIMSS [37] findings revealed that the majority of students (81%) enjoyed or enjoyed studying science. Physics was disliked by students studying different science subjects less than the other science subjects, and (61%) were very optimistic or confident in science, whereas 40% were not confident. Students studying different science topics were less secure in their understanding of physics.

Future Participation in Science

The results of this study showed that students are very interested in continuing to participate in science in the future, as shown by the regional group mean average value of 3.19. The majority of students want to study more science in the future (92%), study science at university (85 %), and work in a science-related field in the future (76 %).

Findings by Genders

Boys in Southeast Asia had marginally higher regional mean average values of 3.04 and 3.01 than girls (see Table 3), suggesting that boys were slightly more optimistic about science than girls. This finding is supported by a number of research that students in general demonstrated a positive attitude toward science and its contribution to society, with male students being more positive than female students [1][5][14][34]. In addition, boys were found to enjoy gaining new knowledge in science (3.51) and to be more interested in learning about science (3.43) than girls in this research, implying similar patterns to PISA (2015)

analyses, which found that boys enjoyed and were more interested in learning science than girls.

In addition, boys in this study (see Appendix B) said that digital technology helps them learn better (3.16), that they enjoy visiting websites (3.13), that they enjoy watching science shows on TV (3.24), and that they enjoy reading science magazines, books, and newspapers to learn about science (3.07) Girls preferred to participate in more science events outside of school, such as forming a science club (3.15), visiting science centres, and participating in science fairs. This result is confirmed by PISA [37], which found that 24 % of boys and 15 % of girls visit science-related websites on a regular basis, and 30 % of boys and 16 % of girls watch science-related TV shows while 11% of boys, and only 6% of girls reported that they regularly attend a science club.

However, only 16% favoured reading science magazines or newspaper articles about science, and 15% preferred following science or environmental news on blogs or microblogging sites. Boys preferred 'topics in chemistry' (3.16), 'nanotechnology' (3.12), 'topics in physics' (3.08), and 'genetic engineering' (3.04), while girls preferred 'human genetics' (3.38) and 'science of ageing' (3.04), according to the report (3.16). This conclusion is backed up by [4][40], who found that research conducted between 1970 and 1991 revealed that boys have a positive attitude. Boys were more interested in physics and chemistry in school than girls, particularly in physics than biology, similar to PISA (2015), study which found that boys were more interested in physics and chemistry while girls were more interested in health-related topics in all countries and economies.

Girls in this study commented that they prefer to work in science related careers than boys. PISA [30] showed that the number one career expectation for boys are police officers compared to girls becoming specialist medical practitioners indicating girls prefer STEM related career aspirations more than boys. According to a PISA survey, more than one in four boys plan to work as an engineer or science professional when they turn 30, but less than one in six girls do[30].

There appeared to be a dissonance between students' attitudes toward science in general and their attitudes toward science as a topic in this field. There seemed to be a disconnect in students' perceptions of science and how school science content is presented in light of technological advances such as computers, cell phones, the internet, and social media and how school science content is presented and taught, as well as how great scientists' lives and achievements are depicted, especially in science textbooks

Science education should place a greater focus on the importance and links of science to daily life in order to foster students' attitudes and involvement in potential participation in science. Technology education and learning should emphasise an interactive, interdisciplinary, and multidisciplinary approach rather than science, scientists, or scientific method and applications of what biologists, chemists, physicists, and other scientists do in order for students to respect and enjoy a potential career in science. STEM curriculum and interventions in schools should be improved, with a focus on the importance of pursuing STEM-related professions in terms of personal and social changes and impacts.

CONCLUSION

Findings by Year Levels

The results revealed that Year 9 and Year 10 students had nearly identical regional average mean values of 3.00 and 3.01 (see Table 7), showing that both groups of students were enthusiastic about science. This research also found that 27 out of 49 survey items with major differences favoured Year 9 students over Year 10 students, with Year 9 students outperforming Year 10 students with a small to medium impact size in most cases. Differences between year levels were more pronounced at the country level in Vietnam and the Philippines, favouring Year 9 students over Year 10. This seems to support research results that show that as students advance through higher grades in secondary school, their level of interest declines.

This finding is further supported by a number of studies that attitudes towards science decline from age 11 onwards [42][5][10][33]. According to Kahle and Lakes, children enter secondary school/junior high school with a positive attitude toward science and a strong interest in science, both of which are undermined by their school science experiences, particularly for girls [17]. Apart from that, that the author found that from the age of nine onwards, there was no change in attitudes toward science [15].

Students' interest in science waned when they moved into middle school, and they lost incentive to pursue their science studies [39]. One explanation for this drop in motivation may be due to the fact that the use of textbooks may lean students towards memorization of scientific concepts.

Most students need to experience science as an active process of engagement for interest in science to be high and to propel a need to know as well as a desire to learn [31]. However, the results of TIMSS [38] revealed that 8th Grade students are less confident in science and less positive about learning than 4th Grade.

Recommendation

Based on this study's results, various stakeholders in science education, such as students, principals, curriculum planners and creators, educational researchers, and textbook authors, must take action. Hence, the following recommendations are suggested.

Science education should aim to develop a holistic person in achieving scientific and technological literacy among the student population as they grow and develop into full adults as well as become responsible and useful citizens of the society. Science education must promote all facets of human development, including cognitive, affective, and psychomotor domains, while also taking into account the learners' context, which includes personal characteristics and socioeconomic status, to name a few.

As part of the school science programme, out-of-school learning should be improved. Science centres, museums, botanical gardens, aviaries, zoos, and nature parks should all be available for students to visit. Field trips will help students envision and understand contentious topics, as well as improve dialogue and cooperation between groups that are at odds. Students study scientific material, cultivate positive attitudes toward science, connect with one another while learning valuable information, and have opportunities to use all of their senses to observe phenomena in real-world settings. School administrators and teachers should form functional science clubs and organisations to provide informal learning opportunities and provide all necessary resources.

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*We would like to acknowledge SEAMEO RECSAM for the funding of this research

APPENDIX A

Table 4

Summary of Regional t-test Results for Items by Categories Showing Significant Differences at p<0.01 Confidence Level between Genders

Category	Girls (N = 3217)		Boys (N = 2158)			
What Students Think About Science	**M**	**SD**	**M**	**SD**	***p* value**	**Cohen 's *d***
Science helps me understand the things around me. (BRN)	3.46	0.55	3.28	0.60	.000	0.31
I learn science better with digital technology. (IDN)	2.78	0.69	2.92	0.76	.003	0.19
I learn science better with digital technology. (PHL)	3.25	0.62	3.40	0.62	.001	0.24
Reasoning skills that are taught in science classes can be helpful to me in my everyday life. (IDN)	3.13	0.54	3.03	0.57	.005	0.18
I am interested in learning about science. (MMR)	3.27	0.49	3.39	0.54	.002	0.23
I am interested in learning about science. (PHL)	3.47	0.52	3.58	0.52	.002	0.21
I am interested in learning about science. (VNM)	3.21	0.64	3.33	0.62	.003	0.19
I enjoy acquiring new knowledge in science. (MMR)	3.33	0.53	3.44	0.54	.004	0.21
I enjoy acquiring new knowledge in science. (PHL)	3.48	0.54	3.63	0.48	.000	0.29
I enjoy acquiring new knowledge in science. (VNM)	3.36	0.60	3.46	0.59	.006	0.17
I would rather be told scientific facts than find them from research or doing experiments. (MMR)	2.65	0.95	2.84	0.90	.006	0.21
I would rather be told scientific facts than find them from research or doing experiments. (VNM)	2.54	0.84	2.72	0.88	.001	0.21
Regional Category Mean Average	3.16		3.25			
Science Outside School						
I would like to do more science activities outside school, e.g. join a science club.(BRN)	3.15	0.79	2.89	0.82	.000	0.32
I like to visit science centres and science museums. (BRN)	3.18	0.79	3.01	0.78	.003	0.22
I like to visit science centres and museums.(IDN)	2.97	0.69	2.74	0.69	.000	0.33

Category	Girls (N = 3217)		Boys (N = 2158)			
What Students Think About Science	**M**	**SD**	**M**	**SD**	***p* value**	**Cohen 's *d***
I like to visit web sites to learn about science. (MMR	2.93	0.63	3.13	0.68	.000	0.31
I like watching science programmes on TV. (PHL)	3.12	0.66	3.24	0,66	.009	0.18
I like watching science programme on TV. (VNM)	3.18	0.69	3.30	0.66	.005	0.18
I like reading science magazine, books and newspapers. (PHL)	3.02	0.67	3.07	0.71	.007	0.07
Regional Category Mean Average	3.08		3.05			
Teaching and Learning Science						
Students learn interesting things in science lessons. (BRN)	3.45	0.62	3.29	0.65	.001	0.25
Students do experiments by following the instructions of the teacher.(BRN)	3.43	0.57	3.31	0.63	.005	0.20
Students do experiments by following the instructions of the teacher. (IDN)	3.28	0.52	3.18	0.59	.003	0.18
The teacher clearly explains the relevance of science and technology concepts to our lives. (IDN)	3.29	0.56	3.14	0,58	.000	0.26
Students learn mostly from textbooks and the teacher lectures. (IDN)	3.08	0.69	2.93	0.74	.001	0.21
Students lean mostly from textbooks and the teacher lectures. (MYS)	3.27	0.62	3.08	0.71	.007	0.29
Students learn mostly from textbooks and the teacher lectures. (VNM)	2.57	0.82	2.73	0.83	.002	0.19
Students research online for information related to the topic being studied. (IDN)	3.13	0.59	3.02	0.66	.006	0.18
The teacher tells stories about the lives of scientists and how they make discoveries. (IDN)	3.16	0.66	3.04	0.67	.006	0.18
Regional Category Mean Average	3.18		3.08			
Self-efficacy in Science						
I like science better than most other subjects at school. (BRN)	2.47	0.80	2.69	0.79	.000	0.28
I like science better than most other subjects at school. (MMR)	2.95	0.69	3.13	0.64	.000	0.27
I like science better than most other subjects at school. (PHL)	2.73	0.72	2.88	0.77	.003	0.20
I like science better than most other subjects at school. (VNM)	2.66	0.76	2.82	0.80	.001	0.21
I find science difficult. (MYS)	2.77	0.76	2.54	0.77	.007	0.30
I find science difficult. (PHL)	2.60	0.67	2.35	0.71	.000	0.36
I learn science quickly.(PHL)	2.75	0.63	2.93	0.64	.000	0.28
I learn science quickly. (VNM)	2.61	0.74	2.82	0.77	.000	0.28
Regional Category Mean Average	2.69		2.77			
How Scientists Work						
Scientists use different types of methods to conduct scientific investigations. (BRN)	3.41	0.56	3.25	0.64	.000	0.27

Category	Girls (N = 3217)		Boys (N = 2158)			
What Students Think About Science	**M**	**SD**	**M**	**SD**	***p* value**	**Cohen 's *d***
Scientific investigations can be conducted using computer technology. (IDN)	3.03	0.60	3.18	0.60	.000	0.25
Scientific ideas can be changed. (IDN)	2.73	0.61	2.85	0.64	.002	0.19
Scientific ideas can be changed. (VNM)	3.18	0.59	3.31	0.58	.001	0.22
All scientists follow the same step-by-step scientific method. (MMR)	2.78	0.73	2.93	0.74	.006	0.20
Scientists DO NOT use their imagination and creativity because these can interfere with objectivity. (THA)	2.63	0.78	2.44	0.84	.004	0.23
Scientists DO NOT use their imagination and creativity because these conflict with their logical reasoning. (VNM)	2.42	0.81	2.56	0.87	.007	0.17
Regional Category Mean Average	2.88		2.93			
Interest in Science Topics						
Topics in physics (BRN)	2.77	0.75	2.98	0.77	.000	0.28
Topics in physics (IDN)	2.81	0.68	2.93	0.72	.007	0.17
Topics in physics (MMR)	3.04	0.63	3.17	0.61	.005	0.21
Topics in physics (PHL)	2.84	0.77	3.10	0.79	.000	0.33
Topics in physics (THA)	2.88	0.80	3.07	0.83	.004	0.23
Topics in physics (VNM)	2.99	0.77	3.22	0.70	.000	0.31
Nanotechnology (BRN)	2.64	0.85	2.88	0.88	.000	0.28
Nanotechnology (MYS)	2.71	0.70	2.93	0.72	.005	0.31
Nanotechnology (MMR)	2.76	0.74	3.14	0.67	.000	0.54
Nanotechnology (PHL)	3.01	0.71	3.35	0.67	.000	0.49
Nanotechnology (VNM)	3.15	0.68	3.28	0.71	.003	0.19
Human biology (BRN)	3.31	0.68	3.14	0.77	.001	0.23
Human biology (PHL)	3.50	0.59	3.37	0.66	.002	0.21
Human biology (THA)	3.32	0.68	3.16	0.68	.003	0.24
Genetic engineering (BRN)	2.74	0.86	2.93	0.84	.003	0.22
Genetic engineering (IDN)	3.03	0.62	2.86	0.69	.000	0.26
Genetic engineering (MYS)	2.91	0.63	3.11	0.56	.002	0.34
Genetic engineering (PHL)	3.11	0.74	3.27	0.72	.002	0.22
Science of ageing (IDN)	3.16	0.56	3.00	0.68	.000	0.26
Geology (MMR)	2.67	0.74	2.89	0.74	.000	0.30
Topics in chemistry (VNM)	3.10	0.82	3.16	0.77	.006	0.19
Science versus religion (THA)	2.89	0.76	2.72	0.86	.007	0.21
Regional Category Mean Average	2.97		3.08			
Future Participation in Science						
I would like to work in a career involving science. (IDN)	3.05	0.83	2.85	0.81	.000	0.24
I would like to work in a career involving science. (VNM)	3.04	0.76	3.16	0.71	.009	0.16
I would like to study science at university. (VNM)	3.16	0.73	3.28	0.70	.009	0.17
Regional Category Mean Average	3.08		3.10			
Overall Regional Category Mean Average	**3.01**		**3.04**			

APPENDIX B

Table 6

Summary of Regional t-test Results for Items in Various Categories with Significant Differences between Year Levels

Category	Year 9 (N= 2900)		Year 10 (N= 2463)			
What Students Think About Science	**M**	**SD**	**M**	**SD**	***p* value**	**Cohen's *d***
Reasoning skills that are taught in science classes can be helpful to me in my everyday life. (IDN)	3.15	0.51	3.01	0.61	.000	0.25
Science is very relevant to me. (IDN)	2.94	0.59	3.05	0.67	.008	0.17
Science is very relevant to me. (THA)	3.15	0.57	3.33	0.58	.000	0.31
I am interested in learning about science. (THA)	3.19	0.57	3.36	0.53	.000	0.31
Science helps me understand the things around me. (THA)	3.28	0.55	3.43	0.56	.001	0.27
I enjoy acquiring new knowledge in science. (THA)	3.25	0.52	3.39	0.56	.001	0.26
Advances in science and technology usually improve people's living standards. (THA)	3.46	0.59	3.60	0.52	.001	0.25
I will use science in many ways when I am an adult. (THA)	3.17	0.57	3.28	0.55	.008	0.20
I would rather be told scientific facts than find them out from research or doing experiments. (IDN)	2.81	0.78	2.69	0.74	.001	0.16
I would rather be told scientific facts than find them out from research or doing experiments. (VNM)	2.71	0.90	2.51	0.81	.000	0.23
Regional Category Mean Average	3.11		3.17			
Science Outside School						
I like to visit web sites to learn about science. (THA)	2.88	0.68	3.09	0.65	.000	0.32
I like to visit web sites to learn about science. (VNM)	3.11	0.74	2.98	0.54	.005	0.20
I like to visit science centres and science museums. (THA)	3.09	0.75	3.28	0.67	.001	0.27
I like to visit science centres and science museums. (VNM)	3.28	0.68	3.15	0.65	.002	0.20
I would like to do more science activities outside school, e.g. join a science club. (THA)	3.08	0.78	3.25	0.70	.004	0.23
I would like to do more science activities outside school, e.g.	3.19	0.72	3.05	0.33	.002	0.22

Category	Year 9 (N= 2900)		Year 10 (N= 2463)			
What Students Think About Science	**M**	**SD**	**M**	**SD**	***p* value**	**Cohen's *d***
join a science club. (VNM)						
I like using social media to access science-related information or to keep up-to-date with science e.g. Facebook, Twitter, and Instagram. (THA)	3.09	0.68	3.24	0.65	.005	0.23
I like reading science magazines, books and newspapers. (VNM)	3.13	0.71	2.99	0.55	.002	0.22
Regional Category Mean Average	3.11		3.13			
Teaching and Learning Science						
Students are required to design how a science question could be investigated in the laboratory. (BRN)	2.90	0.67	2.75	0.69	.003	0.22
Students are required to design how a science question could be investigated in the laboratory. (THA)	3.00	0.69	3.16	0.66	.003	0.24
Students learn mostly from textbooks and the teacher lectures.(BRN)	3.15	0.76	3.33	0.72	.001	0.24
Students learn mostly from textbooks and the teacher lectures. (VNM)	2.77	0.85	2.49	0.78	.000	0.34
Students are engaged in investigations using online resources e.g. virtual laboratory or simulations. (IDN)	2.97	0.68	2.83	0.72	.002	0.20
Students are engaged in investigations using online resources e.g. virtual laboratory or simulations. (THA)	3.02	0.67	3.21	0.63	.000	0.29
The teacher clearly explains the relevance of science and technology concepts to our lives. (IDN)	3.28	0.54	3.15	0.60	.000	0.23
The teacher clearly explains the relevance of science and technology concepts to our lives.(PHL)	3.42	0.59	3.30	0.65	.003	0.19
The teacher clearly explains the relevance of science and technology concepts to our lives. (THA)	3.00	0.71	3.18	0.58	.000	0.28
Students are given opportunities to explain their ideas. (IDN)	3.45	0.53	3.35	0.59	.005	0.18
Students are given opportunities to explain their ideas. (PHL)	3.40	0.59	3.23	0.69	.000	0.26
Students are given opportunities to explain their ideas.(THA)	3.02	0.68	3.19	0.61	.001	0.26
The teacher tells stories about the lives of scientists and how they make discoveries. (PHL)	3.36	0.61	3.21	0.66	.000	0.24
The teacher tells stories about the lives of scientists and how they make discoveries. (THA)	2.88	0.75	3.15	0.65	.000	0.38
Students do experiments by following the instructions of the teacher. (PHL)	3.43	0.57	3.31	0.58	.001	0.21
Students spend time in the laboratory doing practical experiments. (PHL)	3.14	0.65	2.98	0.68	.000	0.24
Students spend time in the laboratory doing practical experiments. (THA)	3.12	0.65	3.31	0.65	.000	0.29
Students are asked to apply a science concept to everyday problems. (THA)	2.93	0.66	3.11	0.65	.000	0.27
Students research online for information related to the topic being studied. (THA)	3.09	0.62	3.22	0.60	.005	0.21
Students learn mostly from textbooks and the teacher lectures. (VNM)	2.77	0.85	2.49	0.78	.000	0.34
Regional Category Mean Average	3.11		3.10			
Self-efficacy in Science						
I like science better than most other subjects at school. (IDN)	2.38	0.67	2.64	0.76	.000	0.36
I like science better than most other subjects at school. (THA)						
I like science better than most other subjects at school.(VNM)	2.63	0.80	2.83	0.80	.001	0.25

Category	Year 9 (N= 2900)		Year 10 (N= 2463)			
What Students Think About Science	**M**	**SD**	**M**	**SD**	***p* value**	**Cohen's *d***
	2.81	0.81	2.64	0.75	.001	0.22
I find science difficult. (PHL)	2.59	0.68	2.44	0.70	.002	0.22
Science is boring. (THA)	2.31	0.80	2.10	0.76	.001	0.27
Science is boring. (VNM)	2.25	0.90	2.04	0.68	.000	0.26
I learn science quickly. (VNM)	2.81	0.78	2.57	0.71	.000	0.32
Regional Category Mean Average	2.54		2.47			
How Scientists Work						
Scientific ideas can be changed. (BRN)	2.86	0.73	3.08	0.66	.000	0.32
Scientists use their imagination and creativity when they analyse and interpret data. (IDN)	3.04	0.65	2.81	0.77	.000	0.32
Scientists use their imagination and creativity when they plan investigations. (IDN)	3.28	0.58	3.15	0.67	.001	0.21
Scientists use their imagination and creativity when they plan investigations. (MMR)	3.36	0.55	3.46	0.54	.008	0.18
Scientists use different types of methods to conduct scientific investigations.(MMR)	3.26	0.55	3.40	0.56	.001	0.25
Scientists use different types of methods to conduct scientific investigations. (THA)	3.14	0.61	3.30	0.60	.000	0.26
Scientists DO NOT use their imagination and creativity because these can interfere with objectivity. (MMR)	2.74	0.70	2.57	0.76	.002	0.23
Scientists DO NOT use their imagination and creativity because these can interfere with objectivity. (VNM)	2.55	0.87	2.26	0.75	.000	0.36
All scientists follow the same step-by step scientific method. (PHL)	2.94	0.84	2.79	0.84	.010	0.18
All scientists follow the same step-by-step scientific method. (VNM)	3.14	0.73	2.89	0.78	.000	0.33
Scientific investigations can be conducted using computer technology.(VNM)	3.23	0.63	3.11	0.65	.002	0.19
Scientists DO NOT use their imagination and creativity because these conflict with their logical reasoning. (VNM)	2.62	0.86	2.33	0.78	.000	0.35
Regional Category Mean Average	3.01		2.93			
Interest in Science Topics						
Topics in chemistry (IDN)	2.75	0.66	2.91	0.68	.000	0.24
Topics in chemistry (THA)	2.90	0.73	3.12	0.68	.000	0.31
Topics in chemistry (VNM)	3.17	0.77	2.97	0.83	.000	0.25
Topics in geology (IDN)	2.98	0.63	2.81	0.70	.000	0.26
Topics in geology (VNM)	3.10	0.75	2.91	0.78	.000	0.25
Science of ageing (IDN)	3.15	0.61	3.01	0.63	.001	0.23
Science of ageing (THA)	3.19	0.61	3.34	0.57	.002	0.25
Science of ageing (VNM)	3.20	0.75	3.03	0.73	.000	0.23
Science versus religion (IDN)	3.22	0.64	3.06	0.71	.000	0.24
Ways scientists design experiments (IDN)	3.13	0.55	2.98	0.66	.000	0.25
The biology of plants (IDN)	3.11	0.63	3.00	0.69	.007	0.17
Climate change (IDN)	3.02	0.62	2.92	0.68	.008	0.15
Topics in chemistry (THA)	2.90	0.73	3.12	0.68	.000	0.31
Topic in chemistry (VNM)	3.17	0.77	2.97	0.83	.000	0.25
Genetic engineering (THA)	2.99	0.74	3.20	0.65	.000	0.30
Genetic engineering (VNM)	3.16	0.72	2.95	0.79	.000	0.28
Climate change (VNM)	3.24	0.72	3.08	0.72	.000	0.22

Category	Year 9 (N= 2900)		Year 10 (N= 2463)			
What Students Think About Science	**M**	**SD**	**M**	**SD**	***p* value**	**Cohen's *d***
Topics in physics (VNM)	3.17	0.71	3.00	0.77	.000	0.23
Science versus religion (VNM)	3.01	0.82	2.78	0.81	.000	0.28
Regional Category Mean Average	3.08		3.01			
Future Participation in Science						
I would like to work in a career involving science. (IDN) I would like to work in a career involving science. (THA)	2.89 2.84	0.81 0.79	3.08 3.20	0.85 0.77	.000 .000	0.23 0.46
I would like to study science at university. (THA)	3.04	0.74	3.26	0.72	.000	0.30
I would like to study more science in the future. (THA)	3.32	0.62	3.45	0.58	.004	0.22
Regional Category Mean Average	3.02		3.25			
Overall Regional Mean Average	**3.00**		**3.01**			