ATTITUDES TOWARD SCIENCE AS MEDIATORS BETWEEN PERCEPTIONS OF CLASSROOM ENVIRONMENT, FAMILY INVOLVEMENT, SELF-EFFICACY, AND SCIENCE ACHIEVEMENT

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Abstract

Previous research has indicated that attitudes influence various factors contributing to scientific achievement. Inadequate performance in science can limit career opportunities, underscoring the importance of comprehending how attitudes towards science can enhance overall scientific achievement. This study explored the mediating effect of attitudes towards science for the relationships between perceptions of science classroom environment, family involvement, and science self-efficacy with science achievement. This research was conducted as a non-experimental quantitative research. Questionnaires from modified established instruments, Test of science-Related Attitudes, What Is Happening In this Class, Family Involvement Questionnaire- High School Version, Sources of science Self-Efficacy, and science Achievement Test, were sent out to participants via Google Form on different days for a span of two weeks. A total of 148 Form 2 lower-secondary school students from various districts in Sabah participated in this study. Data were analyzed using the Partial Least Squares Structural Equation Modeling method. The results revealed that Social Implications of science had a significant positive mediating effect between perceptions of science classroom environment and science achievement. Additionally, there was no significant mediating effect of attitudes toward science on the relationship between science self-efficacy, and family involvement with science achievement. Overall, this study suggests that an aspect of attitudes toward science, the Social Implications of science, was an important mediator between students' perceptions of science classroom environment and science achievement. This meant that students would perform better in science when they perceived their science classroom better, in the condition that they value the implications that science brings to real life.
Keywords: *attitudes toward science, family involvement, science achievement, science classroom environment, self-efficacy*

Introduction

The ability of students to achieve science has been influenced by various factors over the years. These factors include perceptions of the classroom environment, attitudes towards science (Newell et al., 2015), family involvement (Khajehpour & Ghazvini, 2011), and students' self-efficacy (Juan et al., 2018). Numerous studies have explored these factors, but there are still contradictions in understanding the correlations between all variables affecting science achievement. In recent years, there has been a growing concern in Malaysian students' performance in the domains of science and Mathematics. The 2022 Programme for International Student Assessment (PISA) results revealed that Malaysian students performed below the average scores of the Organization for Economic Co-operation and Development (OECD, 2023). This meant that Malaysian students might have a deficiency in problem-solving abilities, which is going to cause problems in the future as Malaysia is in need of high-skilled and knowledgeable human labor.

There is a particular concern for the state of Sabah, which has consistently ranked among the most economically challenged regions in Malaysia. The youth of Sabah need the acquisition of requisite skills to access higher-paying employment opportunities, where academic achievement is crucial for understanding current economic trends. Recent analyses indicate that Malaysian students possess limited scientific knowledge they could apply to real-life situations (Kementerian Pendidikan Malaysia, 2012). Thus, the Malaysian Ministry of Education slowly overhauled its syllabus to lean more towards problem-solving. While criticisms have been directed at the perceived difficulty of the new syllabus under the KSSM framework, analysis of science SPM results from 2018 to 2021 reveals little difference in average grades (Kementerian Pendidikan Lembaga Peperiksaan, 2022). This was despite the fact that in 2019, Sijil Pelajaran Malaysia (SPM) examination was the last batch under the KBSM format. Therefore, while this study considers the new syllabus to be an essential factor, it may not be sufficient in understanding the various reasons that affect students' science achievement.

Research Problem

Several studies have observed the association between attitudes and science achievement (Ali et al., 2013; Dhindsa & Chung, 2003; Ferreira, 2003; Mattern & Schau, 2002; Papanastasiou & Zembylas, 2004). Educators would be able to evaluate potential interventions to increase enrolment in advanced science classes and encourage students to pursue subjects geared towards science careers (Newell et al., 2015). Research suggested that student attitudinal factors, such as liking and valuing science, have a moderate influence on achievement in science, indicating that students with positive attitudes towards science have significantly higher achievement (Amani Abdullah Mubarak & Nordin Abd. Razak, n.d.). Despite Malaysia's goal to have 60% of students enrolled in science courses, this objective has not been achieved since 1967. According to Datuk Seri Madius Tangau, the Minister of Science, Technology and Innovation, lack of interest in science contributes greatly to students' lack of desire to pursue science courses, as indicated in the 2015 Science Report (Lano, 2017). Poor achievement in science may lead to fewer opportunities for pursuing science courses and careers, and this lack of interest reflects students' attitudes toward science. Additionally, previous studies have illustrated the influence of attitudes on various factors contributing to scientific achievement.

Research Focus

The growth and development of students in educational settings are directly related to their achievement. This study aimed to determine science achievement by evaluating students' overall scores on a science test. Several factors that directly affect science achievement were identified, which included the perceptions of science classroom, self-efficacy, and family involvement in their learning. However, an indirect factor may be influencing these three variables, such as attitudes towards science. Attitudes towards science have been proven to significantly impact students' science achievement (Ali et al., 2013; Hacieminoglu, 2016; Papanastasiou & Zembylas, 2002).

Attitudes toward science refer to the evaluation of science learning domains (Aydeniz & Kotowski, 2014). Osborne et al., (2003) listed a wide-ranging measure of attitudes towards science based on previous studies, which included the perception of science teachers, students' feeling of anxiety concerning science, the value of science, self-esteem, motivation, enjoyment, peers' and parents' attitudes towards science, the classroom environment, science achievement, and failure apprehension (Osborne et al., 2003). In essence, attitudes towards science denote students' perceived behavior towards science. When students perceive that positive behavior towards science is acknowledged and rewarded, there is a higher likelihood of sustained positive engagement (Ajzen, 1991). Consequently, this impact extends to their motivation to acquire scientific knowledge, thus influencing their performance in science examinations. Evaluating students' attitudes toward science can be achieved by appraising their perception of the subject's significance in daily life, manifestation of scientific attitudes, and overall enjoyment of the subject. These factors are connected to students' experiences in science, including their classroom environment, confidence in the subject, and upbringing. By comprehending these elements, educators can create interventions to improve students' attitudes toward science and promote their interest and motivation to learn the subject.

The environment in a science classroom is an important factor that can influence attitudes towards science. This psychosocial environment is formed by different social contexts and teachers' style of instructions and behaviors (Miller & Cunningham, 2011). Attitudes and behavior are closely connected. Students who exhibit positive behavior and have positive expectations generally view their classroom environment positively. Previous studies have demonstrated that students perform better academically with positive perceptions of their classroom environment (Ahmed et al., 2018; Aluri & Fraser, 2019; Nolen, 2003; Robinson & Fraser, 2013) and improve their attitudes towards science (Akinbobola, 2009; Chang et al., 2011; Houston et al., 2003; Kaya & Geban, 2011; Koul & Fisher, 2003; Logan & Skamp, 2013; Ovute & Ovute, 2015; Özkal et al., 2009; Robinson & Fraser, 2013). Attitudes towards science can shape students' perceptions regarding their science classroom environment, which can be assessed through their perceptions of their teachers, classroom tasks, cooperation, and treatment in class. Therefore, the first hypothesis is that positive attitudes towards science can lead to better perceptions of the science classroom environment. By understanding how science classroom environment affects attitudes towards science, educators can design interventions that foster positive attitudes and perceptions, which can potentially enhance students' academic success and engagement in science.

Family involvement can play a role in students' science achievement, as attitudes towards science can be influenced by the attitudes of their parents. According to Gordon (1977), parents act as decision-makers, paid paraprofessionals, bystanders, classroom volunteers, teachers at home, and even learners. Previous research has shown that parental support positively affects students' academic achievement and attitudes towards science (Arulmoly & Kiruthika, 2017; Khajehpour & Ghazvini, 2011; Maphoso & Mahlo, 2014; Mohr-Schroeder et al., 2017; Olatoye & Ogunkola, 2008; Oluwatelure & Oloruntegbe, 2010; Shute et al., 2011; Zainudin et al., 2012). Some forms of parental involvement would be home supervision, school participation, home discussion, and school communication (Berthelsen & Walker, 2008). The attitudes of students towards science are influenced by their own expected outcomes of their actions. When students anticipate positive reactions from their parents regarding their science achievements, they are likely to be more motivated to excel, resulting in a more favorable attitude toward science. This proposition constitutes the foundation for the second hypothesis in this study.

Positive attitudes and motivation in learning are important signs of academic success, which can be seen through favorable attitudes. In science education, students' confidence in their abilities is referred to as science self-efficacy. Science self-efficacy refers to students' beliefs about their aptitudes to succeed at different levels in science subjects, which influences their experiences during science lessons (Bandura, 1993). So, students with positive attitudes tend to feel confident in their capability to excel in science, and this, in turn, can affect their science performance. Previous research has shown that high science self-efficacy affects science achievement positively (Aslam & Ali, 2017; Hwang et al., 2018; Kung, 2009; Sucuoğlu, 2018). Science self-efficacy can be measured by examining students' experiences, the performance of others, the impact of that performance on the student, students' emotions, and perceived encouragement from others. The third hypothesis for this study was formed by examining the effect of science self-efficacy to attitudes towards science.

Research Aim and Research Questions

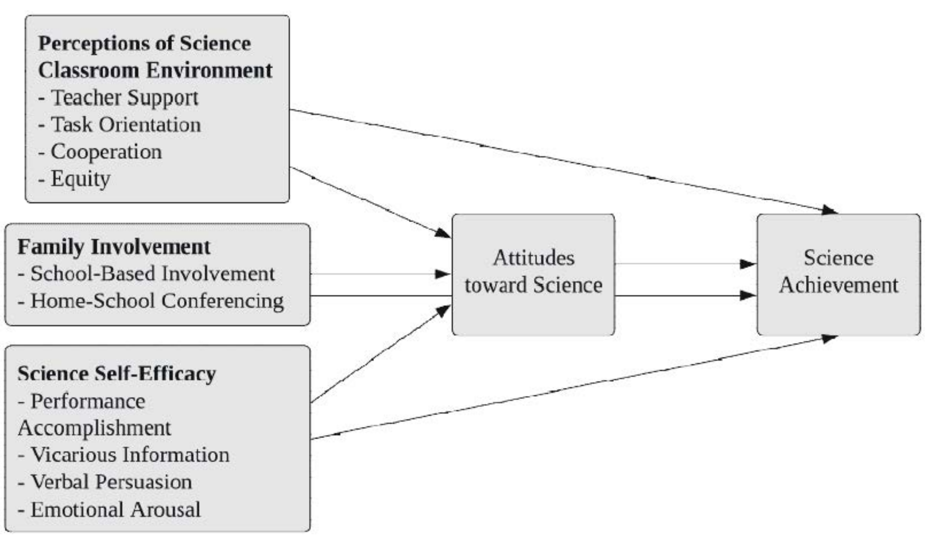
The research aim was to determine the mediating effect of attitudes towards science for the relationships of perceptions of science classroom environment, family involvement, and science self-efficacy with science achievement.

This study addressed the following research questions;

i. Does attitude towards science mediate the relationship between perceptions of science classroom environment and science achievement among Form 2 students?
ii. Does attitude towards science mediate the relationship between family involvement and science achievement among Form 2 students?
iii. Does attitude towards science mediate the relationship between self-efficacy and science achievement among Form 2 students?

Figure 1 shows all the independent and dependent variables, as well as attitudes towards science as the mediator. The aspects of each variable would be measured to represent the perceptions of the science classroom environment, family involvement and science self-efficacy.

Figure 1
Conceptual Framework



Research Methodology

General Background

The research design used in this study was non-experimental quantitative research, where the researcher cannot manipulate or control the independent variables because its exhibition has already occurred (Lay & Khoo, 2014). For this study, a survey research design was employed, and questionnaires were used to collect the necessary data. Survey research was employed to survey the thoughts, feelings, and behaviors of specific groups of individuals (Lay & Khoo, 2014). Researchers can examine the attitudes, beliefs, perceptions, and behaviors of targeted samples through the use of questionnaires. Questionnaires offer advantages, including the ability to provide a comprehensive view from a larger population with a smaller sampling-range error, the option of being mailed, cost-effectiveness, wider reach, and the capacity to cover extensive geographic areas (Cargan, 2007).

The participants for this study were Form 2 students in Sabah. It was assumed that the students were in an environment with the same rules, regardless of their schools, and that individuals around them affected them differently. This adhered to the second assumption of the positivist approach. The students answered the questionnaires based on their experiences within the Science classroom, their self-efficacy, and their family involvement. This adhered to the third assumption, where the researcher relied fully on the students to make their own decisions and interpret their own experiences. The researcher acted as a neutral observer, in accordance with the positivist research theory. The data collection was carried out using Google Forms within two to three weeks. This was set up to avoid fatigue when answering questionnaires. Teachers were also appointed to help with data collection for Science Achievement Test, in order to simulate a written examination test where students were not allowed to refer to textbooks when answering Science questions.

This study was guided by two main theories: Bandura's Social Cognitive Theory and the Theory of Educational Productivity. In the Social Cognitive Theory, it was believed that humans had developed a strong ability to learn through direct experiences by observing people's actions and their outcomes (Bandura, 1989). On the other hand, the Theory of Educational Productivity was an empirical test that examined how different factors contribute to the effectiveness of production (Walberg, 1982). In this study, production referred to achievement in Science. Additionally, the study considered how students' perceptions of science classroom environment, family involvement, and science self-efficacy impact their social cognitive development, which then would impact their Science achievement.

Sample

Cluster sampling was used as the sampling method for this research. This was a probability sampling procedure where population elements were selected randomly from naturally occurring groupings called clusters (Daniel, 2012). In this study, multistage cluster sampling was used to select the sample.

The population comprised 6000 Form 2 lower-secondary school students from several districts in Sabah, which were Kota Kinabalu, Ranau, Kota Belud, Tenom, Keningau, Beluran, Kuala Penyu and Kunak. Firstly, through random sampling, three zones out of five in Sabah were treated as the first clusters; the West Coast Division, the Interior Division, and the Sandakan zone. Then, random sampling was used to pick several districts from each zone. The districts Kota Kinabalu, Ranau, Kota Belud, Tenom, Keningau, Beluran, Kuala Penyu and Kunak were chosen as the second clusters. Afterwards, four schools from each district were chosen as the third clusters. From each school, two classes were selected as the final clusters, where ten or more students from each class would be participating. The final sample was 200 Form 2 students.

This study examined Form 2 students in Sabah who were taught the same national science syllabus. Form 2 students were selected as the sample group because they were already accustomed to the atmosphere of secondary schools and could provide valuable insights on their experiences in lower secondary classroom environment, their family involvement, and their self-efficacy in science.

Instrument and Procedures

The questionnaires involved in this study were the Test of Science-Related Attitudes (TOSRA) to measure attitudes toward science (Fraser, 1981). The What is Happening In this Class? (WIHIC) to measure students' perceptions of the science classroom environment (Fraser, 2012). The Family Involvement Questionnaire-High School Version (FIQ-HS) to measure family involvement or parental support (Fantuzzo et al., 2000). The Sources of Science Self-Efficacy (SSES) to measure students' self-efficacy in science subject (Lent & Lopez, 1996). Science achievement was measured using the Science Achievement Test instrument, which was built based on the Malaysian Science syllabus for Form 2. The questionnaires were adapted and modified to align with the Malaysian education system. The adaptation process began with translating the questionnaires into Malay. Subsequently, a pre-test was conducted using a bilingual format, involving 30 students. Items identified as having translation ambiguities were refined accordingly. Following this, a pilot test was carried out to evaluate and ensure the reliability and validity of the questionnaires.

Questionnaires can be easily distributed and completed by a large number of participants, which makes it a practical method for collecting data. Moreover, participants can be truthful with their responses due to the anonymous nature of questionnaires (Cargan, 2007). The questionnaires selected for this study were modified and pilot-tested prior to data collection with the main sample. These modifications aimed to align the instruments with the students' cultural, educational, and social contexts, ensuring relevance and clarity. Additionally, only the most pertinent items were retained to minimize respondent fatigue, facilitating more accurate data collection. Given the relatively older nature of these instruments, pilot testing was essential to verify that the modified versions retained acceptable levels of reliability and validity. Table 1 presents the reliability and validity metrics of the questionnaires following modification.

Permission was obtained from relevant authorities and schools before the study was conducted. In order to conduct any research involving students, permission must be granted by the Malaysian Ministry of Education. Afterwards, further permission must be applied from Sabah's Department of Education. Then, the principals of the chosen schools were contacted before proceeding with any data collection. Teachers who were selected by the principals to assist in data collection were briefed by the researchers. The teachers then explained to students that the instruments were not for grading purposes, and stressed to students of their anonymity.

The questionnaires were sent out to teachers via Google Form, who later carried out data collection with their students. After three weeks, the data was obtained from Google in Excel form, and streamlined before analysis was conducted. Participants who did not complete either the questionnaires or Science achievement test were removed from the final analyzed data set. Before PLS-SEM was applied, the reliability and validity were established. This was done through the SmartPLS 4. The reliability of the instruments was established using composite reliability.

Table 1
Reliability and Validity of Modified Questionnaires

Variables	*N*	Cronbach's Alpha	Composite Reliability (rho_c)	*AVE*
Test of Science-Related Attitudes	12	.911	.924	.178
Social Implications of Science	10	.797	.867	.274
Adoption of Scientific Attitudes	10	.761	.848	.280
Enjoyment of Science Lessons	10	.872	.913	.418
What Is Happening In this Class?	28	.883	.919	.679
Teacher Support	8	.920	.934	.641
Task Orientation	7	.919	.934	.639
Cooperation	5	.932	.924	.686
Equity	8	.945	.954	.724
Family Involvement Questionnaire – High School	22	.836	.903	.757
School-based Involvement	13	.854	.877	.401
Home-School Conferencing	9	.912	.916	.328
Sources of Science Self-Efficacy	9	.658	.768	.175
Performance Accomplishments	2	.496	.799	.198
Vicarious Information	2	.179	.707	.214
Verbal Persuasion	3	.634	.798	.258
Emotional Arousal	2	.483	.794	.356

Afterwards, the Average Variance Extracted (AVE) were examined for convergent validity. From the analysis, the Sources of Science Self-Efficacy recorded the lowest reliability but was still within the acceptable range for both Cronbach's Alpha and composite reliability. The rest of the questionnaires scored more than .90, which was still very acceptable. Convergent validity was established through outer loadings, indicator reliability and AVE. Hair et al. (2017) ruled that outer loadings should be more than .70, indicator reliability should be more than .50, and AVE should be more than .50 to be acceptable. The instruments' validity was established through the composite reliability of more than .70 (Fornell & Larcker, 1981). Then, discriminant validity was determined through cross-loadings analysis, Fornell-Larcker Criterion, and HTMT Ratio.

Table 2
Tolerance and VIF Values

Set	Constructs	Tolerance	VIT
1	WIHIC	0.690	1.450
	FIQ-HS	0.649	1.540
	SSES	0.855	1.170
2	SIS	0.338	2.955
	ASA	1.339	1.747
	ESL	0.401	2.491
3	WIHIC	2.611	2.383
	FIQ-HS	0.649	1.541
	SSES	0.816	1.225
	SIS	0.338	2.955
	ASA	1.339	1.747
	ESL	0.401	2.491

Table 2 shows the VIF result from SmartPLS 4. It shows that none of the constructs yield tolerance values of less than 0.2 and VIF values of less than 5. This meant that the constructs had no collinearity problems.

Data Analysis

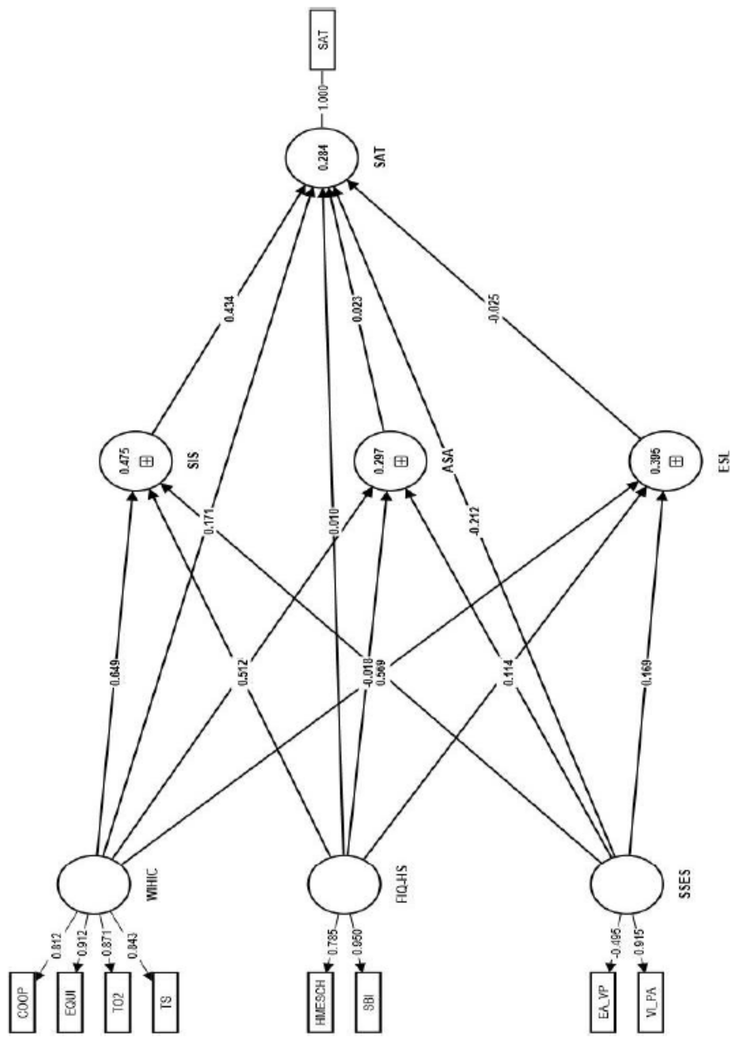
After ensuring the reliability and validity were established, an analysis of the structural model was conducted. For the first step, collinearity assessment was to examine each set of predictor constructs separately for each subpart of the structural model. According to Hair et al. (2017), a predictor construct would have critical levels of collinearity if it has tolerance values below 0.20 and a Variance Inflation Factor above 5.0. Specifically, WIHIC, FIQ-HS, SSES, SIS, ASA, and ESL as predictors of SAT.

Research Results

The measurement model captured the relationships between latent variables and their corresponding measures, with the indicators representing a sample of all possible items within the construct's conceptual domain (Hair Jr. et al., 2017). The path coefficients between WIHIC, FIQHS, SSES, and the three dimensions of attitudes toward Science (Social Implications of Science, Adoption of Scientific Attitudes, and Enjoyment of Science Lessons) with Science achievement are illustrated in Figure 2.

Figure 2

Path Coefficients Result



Note: COOP=Cooperation, EQUI=Equity, TO=Task Orientation, TS=Teacher Support, HMESCH=Home-School Conferencing, SBI=School-Based Involvement, EA_VP= Emotional Arousal and Verbal Persuasion, VI_PA= Vicarious Information and Performance Accomplishments, WIHIC=Perceptions of Science Classroom Environment, FIQ-HS=Family Involvement, SSES=Sources of Science Self-Efficacy, SIS=Social Implication of Science, ASA=Adoption of Scientific Attitudes, ESL=Enjoyment of Science Lessons, SAT=Science Achievement

For this study, coefficients of determination (R^2) and effect sizes were reported. For R^2, Cohen (1988) suggested that if it falls within the range of 0.02 – 0.12, it would have a small effect, a medium effect in the range of 0.13 – 0.25, and a large effect in the range of 0.26 and above. From Figure 2, the R^2 value for SAT is .284, which means 28.4% variance is explained by WIHIC, FIQ and SSES, and attitudes toward science's SIS, ESL and ASA, which is large according to Cohen (1988). WIHIC (β = .171), FIQ-HS (β = .010), and SSES (β = -0.212) all had a positive effect on SAT, but none of them was significant. It was also found that SIS (β = .434), and ASA (β = .023) affect SAT positively, while ESL (β = -0.025) affect SAT negatively.

However, only SIS yielded a significant result. WIHIC, FIQ and SSES explained SIS by 48.8%, ASA by 56.7%, and ESL by 54.7%.

Table 3
Relationships in the Structural Model's Direct Effects

Correlation	Standard beta, β	Standard error, σ	*t*-value	Effect size, f^2	Findings
WIHIC -> SAT	0.171	0.099	1.723	.017	No
FIQ-HS -> SAT	0.010	0.095	0.101	.000	No
SSES -> SAT	-0.212	0.120	1.771	.051	No
SIS -> SAT	0.434	0.110	3.937	.066	Yes
ASA -> SAT	0.023	0.099	0.230	.000	No
ESL -> SAT	-0.025	0.105	0.237	.000	No

Note: *Significant at $p < .05$; **Significant at $p < .01$, Bootstrapping (n=5000)
WIHIC=Perceptions of Science Classroom Environment, FIQ-HS=Family Involvement, SSES=Science Self-Efficacy, SIS=Social Implications of Science, ASA=Adoption of Scientific Attitudes, ESL=Enjoyment of Science Lessons, SAT=Science Achievement

Table 3 also presented the effect sizes for all combinations of endogenous constructs and corresponding exogenous. Cohen (1988) categorized effect sizes of more than .02 as small, more than .15 as medium, and more than .35 as large. In Table 3, almost all of the f^2 values were small, and none of the exogenous variables had any effect on SAT, with effect sizes ranging from .000 to .066.

Table 4
Mediating Effects of Attitudes toward Science on the Relationship between Perceptions of Science Classroom Environment and Science Achievement

Correlation	Standard beta, β	Standard error, σ	*t-value*	Confidence Intervals	Findings
WIHIC -> SIS -> SAT	0.282	0.077	3.671	LL: 0.132 UL: 0.434	Supported
WIHIC -> ASA -> SAT	0.012	0.052	0.226	LL: -0.090 UL: 0.114	Not supported
WIHIC -> ESL -> SAT	-0.014	0.060	0.235	LL: -0.128 UL: 0.108	Not supported

Note: *Significant at $p< .05$; **Significant at $p< .01$, Bootstrapping (n=5000)
WIHIC=Perceptions of Science Classroom Environment, SIS=Social Implications of Science, ASA=Adoption of Scientific Attitudes, ESL=Enjoyment of Science Lessons, SAT=Science Achievement

Going into the mediating effect, the standard beta, standard deviation, *t*-value, confidence intervals and findings were discussed. Table 4 showed the mediating effect all aspects of attitudes toward Science had on the relationship between perceptions of Science classroom environment and Science achievement. The indirect effect for WIHIC to SAT through SIS yielded β = 0.282, which was significant with *t*-value = 3.671. The 95% Boot CI: LL = 0.132, UL = 0.434] did not include the value 0. Thus, it can be concluded that there was a significant mediating effect of Social Implications of Science between the perceptions of science classroom environment and science achievement among Form 2 students. Meanwhile, the indirect effect for WIHIC to SAT through ASA (β = 0.012, *t*-value = 0.226, 95% Boot CI: LL = -0.090, UL = 0.114), and ESL (β

= -0.014, *t*-value = 0.060, 95% Boot CI: LL = -0.128, UL = 0.108) involved the value of zero, thus there was no mediating effect.

Table 5
Mediating Effects of Attitudes toward Science on the Relationship between Family Involvement and Science Achievement

Correlation	Standard beta, β	Standard error, σ	*t*-value	Confidence Intervals	Findings
FIQ-HS -> SIS -> SAT	-0.008	0.034	0.228	LL: -0.078 UL: 0.065	Not supported
FIQ-HS -> ASA -> SAT	0.000	0.010	0.041	LL: -0.019 UL: 0.025	Not supported
FIQ-HS -> ESL -> SAT	0.000	0.007	0.059	LL: -0.014 UL: 0.017	Not supported

Note: *Significant at $p< .05$; **Significant at $p< .01$, Bootstrapping (n=5000)
FIQ-HS=Family Involvement, SIS=Social Implications of Science, ASA=Adoption of Scientific Attitudes, ESL=Enjoyment of Science Lessons, SAT=Science Achievement

The bootstrapping analysis in Table 5 showed that the indirect effect for family involvement in science achievement through SIS (β = -0.008, *t*-value = 0.228, 95% Boot CI: LL = -0.078, UL = 0.065), ASA (β = 0.000, *t*-value = 0.041, 95% Boot CI: LL = -0.019, UL = 0.025), and ESL (β = 0.000, *t*-value = 0.059, 95% Boot CI: LL = -0.014, UL = 0.017). The 95% Boot CI for SIS, ASA and ESL included the value of zero, thus there was no mediating effect for all aspects of attitudes toward science.

Table 6
Analysis of Attitudes toward Science as Mediator Between Science Self-Efficacy and Science Achievement

Correlation	Standard beta, β	Standard error, σ	*t*-value	Confidence Intervals	Findings
SSES -> SIS -> SAT	0.058	0.039	1.508	LL: -0.049 UL: 0.126	Not supported
SSES -> ASA -> SAT	0.003	0.015	0.176	LL: -0.033 UL: 0.030	Not supported
SSES -> ESL -> SAT	-0.004	0.020	0.215	LL: -0.043 UL: 0.038	Not supported

Note: *Significant at $p < .05$; **Significant at $p < .01$, Bootstrapping (n=5000)
SSES=Science Self-Efficacy, SIS=Social Implications of Science, ASA=Adoption of Scientific Attitudes, ESL=Enjoyment of Science Lessons, SAT=Science Achievement

In Table 6, the mediating effect of attitudes toward science between science self-efficacy and science achievement was reported. The bootstrapping analysis in Table 5 showed that the indirect effect for SSES to SAT through SIS (β = 0.058, *t*-value = 1.508, 95% Boot CI: LL = -0.049, UL = 0.126), ASA (β = 0.003, *t*-value = 0.176, 95% Boot CI: LL = -0.033, UL = 0.030), and ESL (β = -0.004, *t*-value = 0.215, 95% Boot CI: LL = -0.043, UL = 0.038). The 95% Boot CI for SIS, ASA and ESL involved the value of zero, thus there was no mediating effect for all relationships.

Discussion

Educators and researchers evaluate science achievement to assess students' understanding of scientific concepts. Over the years, a wide range of factors has been explored in relation to academic achievement, to identify strategies to improve science achievement. This broader context is essential to consider when interpreting the findings of this study, which focuses specifically on science achievement. Among the various factors examined, students' attitudes toward science have emerged as particularly significant, strong influence on academic performance in the subject. Many research studies found that positive attitudes towards science were usually followed with good academic performance (Olasehinde & Olatoye, 2014; Hacieminoglu, 2016). Nonetheless, more research on the indirect effect of attitudes towards science achievement should be done as attitudes could be influenced by other factors important in influencing science achievement.

The result from the data shows one of the components of attitudes towards science can mediate the connection between perceptions of science learning environment and science achievement. The aspect of attitudes towards science, which was the Social Implication of Science, moderated the perceptions of science classroom environment to science achievement. Meanwhile, the Adoption of Scientific Attitudes and Enjoyment of Science Lessons did not mediate the relationship between perceptions of science classroom environment and science achievement. This finding is consistent with Siti (2012), who found that students' valuing science was a strong predictor of science achievement. Students tend to achieve greater learning outcomes in science classrooms where they recognize the societal benefits of scientific knowledge. Teachers can nurture this awareness through interactive learning processes and effective communication, fostering a deeper appreciation for science and its impact. This is also supported by Hafizoglu and Yerdelen (2019), who found that a classroom that utilized a constructivist learning style could increase students' science achievement. This study's finding is also in line with Tosto et al. (2016), who found that intrapersonal factors, like interest, mediated the connection between perceived classroom environment and maths performance. Interest could be seen as an attitude towards science, as an attitude closely related to the forming of behavior.

Based on the findings, there was no significant mediating effect of attitudes towards science between family involvement and science achievement. Social Implications of Science yielded a weak negative mediating effect on the relationship between family involvement and science achievement. However, the effect of Social Implications of Science as a mediator was not a significant one. The findings of this study contradict several studies which found that students developed better attitudes towards science if their families were involved in their academic lives (Arulmoly & Kiruthika, 2017; Mohr-Schroeder et al., 2017; Oluwatelure & Oloruntegbe, 2010). Parents with low levels of involvement often do not encourage their children to attend private lessons or establish regular study habits, which can hinder students' ability to make meaningful academic progress (Oluwatelure & Oloruntegbe, 2016). This finding suggests that positive attitudes toward science may not be essential for family involvement to influence science achievement, or that family involvement itself may not be a critical factor in ensuring students' success in science. It indicates that students might perform well in science and maintain positive attitudes toward the subject even with minimal family involvement. However, further research is necessary to clarify these relationships and their potential impact on science achievement.

The findings showed all aspects of attitudes towards science did not mediate the association between science self-efficacy and science achievement. However, some context from previous studies could still be referred to understand the result of this research. Roebianto (2020) found that although attitudes toward science positively affect science achievement, self-efficacy could still have a negative effect. This could explain the negative relationship between science self-efficacy and science achievement mediated by the Enjoyment of Science Lessons. Students may exhibit high enthusiasm for science lessons. However, this enthusiasm might lead them to overestimate their actual skills and knowledge in the subject. Roebianto (2020) also discussed that enjoyable science lessons did not affect students' performance in science academic. Thus, prioritizing students' mastery of the subject is more important than solely fostering their enjoyment of classroom lessons. This is further supported by a study by Zhang et al. (2022), which found that when students focus on mastering the subject rather than solely on performance, their academic engagement is positively impacted.

A possible explanation for this finding lies in the structure of Malaysia's science examinations under the KSSM framework. Recent revisions to the standardized exam format aim to create a fairer assessment for students of diverse abilities. Moving away from the traditional reliance on multiple-choice and close-ended questions, the revised format includes fewer multiple-choice items and introduces a blend of close-ended and open-ended questions with a contextual focus. This shift reduces the emphasis on rote memorization, prioritizing higher-order thinking by requiring students to explain natural phenomena using scientific concepts. The new format also incorporates questions rooted in real-life situations, which has been shown to enhance students' overall performance in science. Assessments that draw on students' real-world experiences may contribute meaningfully to improved science achievement. This was supported by a study done by Nurul et al. (2021), where it was found that implementing contextual teaching and learning model can increase students' learning achievement in Science learning.

Additionally, there is a growing emphasis on formative assessments rather than exclusive reliance on summative evaluations in final exams to support strong academic performance. Teachers face continual pressure to facilitate the success of all students and are expected to implement targeted interventions to assist those who are struggling. The varying levels of effort exerted by students may also impact their achievements. This focus on formative support, along with supplementary classes and additional assistance from science teachers, could contribute to a reduced influence of students' attitudes toward science on their academic outcomes. Schneider et al. (2022) discuss how positive outcomes in science achievement can be fostered through a principled design system that integrates an engaging curriculum, high-quality professional development, and formative assessments aimed at stimulating knowledge acquisition. As a result, students' attitudes toward science may have a diminished effect on their performance due to the extensive provision of supplementary classes and targeted support focused on examination success.

Conclusions and Implications

The findings suggest that certain aspects of attitudes toward science play a mediating role in the relationships between perceptions of the science classroom environment, family involvement, science self-efficacy, and science achievement among Malaysian students. This phenomenon may be influenced by the predominant reliance on written examinations in the Malaysian assessment system and the significant support provided by teachers to enhance student performance across varying proficiency levels. Furthermore, the KSSM examination format appears to offer opportunities for less proficient students to succeed by including questions on topics in which they may have stronger abilities. However, the findings do not conclusively determine whether these factors have enhanced accessibility to science education or whether the science examinations effectively assess the diverse abilities of students. Therefore, further in-depth research is necessary to explore these issues in greater detail.

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The results of this study suggest that science achievement can be improved despite students' attitudes toward science. It is important for teachers to provide students with effective learning opportunities and not rely solely on their attitudes to help them excel in science. Relying solely on standardized examinations may prove insufficient in assessing academic achievement, highlighting a potential limitation in how educators evaluate students' science performance. This emphasizes the need for Malaysian educators to explore more effective pedagogical strategies to foster meaningful science learning. While students' attitudes toward science remain important, teachers can enhance student success by adopting improved evaluation methods, engaging classroom activities, and effective teaching techniques. Ultimately, the way in which students acquire and apply knowledge is a more reliable indicator of academic achievement than their attitudes toward the subject.

Although this research was conducted in Malaysia, the findings offer significant international relevance, particularly for countries facing similar educational and economic challenges. The variables explored are universal elements in education, making insights from the Malaysian context valuable in understanding how these factors interact in different settings. Apart from that, Malaysia's recent educational reforms, aimed at enhancing problem-solving skills, provide a real-world case study on the impacts of curriculum overhauls in developing countries. This context is especially important in light of the below-average performance of Malaysian students in international assessments like PISA, which resonates with similar educational challenges faced by other nations. Moreover, the state of Sabah demonstrates how education can be critical to economic advancement for under-resourced regions, underscoring the role of academic success in social mobility. Insights from Malaysia's experience can inform global conversations about addressing achievement gaps, optimizing curriculum design, and balancing academic rigor with accessibility–issues that are increasingly relevant as countries strive to equip students with skills to succeed in a complex, competitive world.

Several recommendations for future research can be made based on the findings of this study. Firstly, the first one was to conduct a longitudinal study to see how attitudes toward science as a mediator and even its effect on science achievement could change over the years. Secondly, quantitative research could be complemented with qualitative investigations to explore the experiences and perceptions of students in-depth. Thirdly, future research could focus on differential impact on diverse student groups, where attitudes toward science may vary among different student groups, in terms of gender, socio-economic background, and cultural diversity. Lastly, it would be interesting to explore the different impact on science achievement by comparing the KSSM and KBSM exam format, to see if there is a significant difference between the two syllabuses. These areas of research can provide a comprehensive understanding of the factors contributing to students' science achievement and are beneficial in order to develop effective strategies to improve science education.

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Declaration of Interest

The authors declare no competing interest.

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