Perceived Teacher Professional Development and 21st Century Skills as Predictors on Students Motivation in Science

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Abstract

The low motivation of students to learn science has been a concern for many science educators. This study determined the combined significant influence of perceived teacher professional development and 21st-century skills on students' motivation in science. This study employed a quantitative design using descriptive-predictive approach involving 150 samples using a survey questionnaire. This study found that perceived teacher professional development and 21st-century skills among Grade 11 students were very high. Moreover, students' motivation in science was high. Furthermore, there is a combined significant influence of perceived teacher professional development and 21st-century skills on students' motivation in science. However, this conclusion does not fully support the self-determination theory since only one independent variable is found to be correlated with the dependent variable. This study recommends that teachers should help students connect science with other subjects and real-world scenarios. By incorporating interdisciplinary projects and inquiry-based learning experiences, students can become more engaged and find the learning process more relevant.

Keywords: Perceived professional teacher development; 21st century skills; students motivation in science ; regression analysis; Philippines

1. Introduction

Teachers have long noticed students' lack of motivation (Howley-Rouse, 2023). Studies over the past few decades have indicated a general tendency for students' motivation to engage with science, in and out of school, to decrease during adolescence (Fortus & Touitou, 2021). Moreover, studies have shown evidence of many young students losing motivation to learn science in middle school as they advance in their education (Meyers, 2021). Globally, a pervasive lack of motivation in learning science has been observed. In the United States, Vietnam, and Malaysia, research has shown a gradual decline in students' motivation to learn science from primary to upper secondary education (Lee et al., 2016; Chan & Norlizah, 2017; Van & Csapó, 2022). In Taiwan, the decline in students' motivation is particularly evident in physical science, with a study identifying seven different motivational trajectories and their impact on science-related outcomes (Wang et al., 2017). In the Philippines, however, most students are unmotivated to learn, complete their modules, and perform the expected tasks in science (Beboso & Bual, 2022).

Students who lack interest or motivation will see no value in the course or its content, irrespective of the objective value of an activity or topic (Capunitan et al., 2023). Moreover, lacking motivation prevents deep and effective learning (Yilmaz et al., 2017). Given this assertion, it is urgent to explore and address the problem of poor motivation of students in learning science. Moreover, there is a pressing need to address the issue, but the problem is that there is insufficient research available, particularly in the context of the local setting. These challenges triggered the conduct of this study. This study is anchored on the Self-determination Theory of Deci and Ryan (1985), which states that intrinsic and extrinsic factors influence student motivation. In this study, the perceived teacher professional development is applied as the variable for extrinsic factors. In contrast, 21st-century skills are used as the internal element determining students' motivation in science.

The conceptual framework of the study is shown in Figure 1. As seen in Figure 1, the first independent variable is perceived teacher professional development with eight indicators: orientation, configuration, questioning, teaching modeling, application, learning environment, management of time, and assessment (Bozkuş (2019). The second independent variable is 21st-century skills with four indicators: collaboration, critical thinking, creativity, and communication (Kelley et al., 2019). On the other hand, the dependent variable is students' motivation with six indicators: self-efficacy, active learning strategies, science learning values, performance goal, achievement goal, and learning environment stimulation (Tuan et al., 2005). The arrow connecting the three variables signifies the assumed relationship.

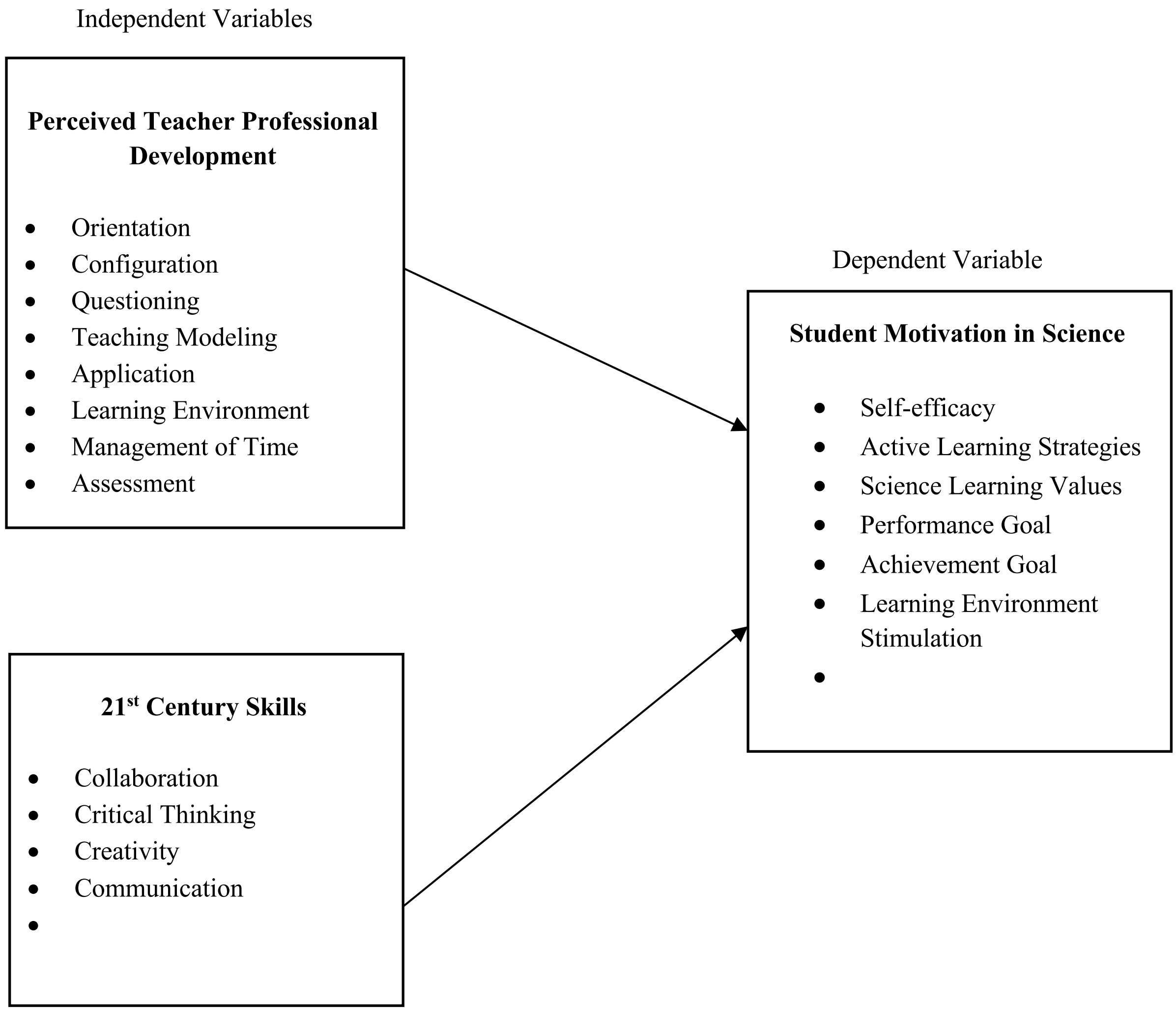

Figure 1. Conceptual Framework of the Study

This study determined the combined significant influence of perceived teacher professional development and 21st-century skills on students' motivation in science during the school year 2023-2024. Specifically, it aims to answer the following objectives: to describe the level of teacher professional development as perceived by students in terms of: orientation, configuration, questioning, teaching modelling, application, learning environment, management of time, and assessment. To ascertain the level of perceived 21st-century skills in terms of: critical thinking, collaboration, communication, and creativity. To determine the level of students' motivation in science in terms of: self-efficacy, active learning strategies, science learning values, performance goal, achievement goal, and learning environment stimulation. Moreover, to determine the significant relationship between perceived teacher professional development and students' motivation in science, and the significant relationship between perceived 21st-century skills and students' motivation in science. The following null hypotheses were tested at 0.05 level of significance: H_{o1}. There is no significant relationship between perceived teacher professional development and students' motivation in science. H_{o2}. There is no significant relationship between perceived 21st century skills and students' motivation in science. H_{o3}. There is no combined significant influence of perceived teacher professional development and 21st-century skills on students' motivation in science.

2. Method

This study employed a quantitative research design with a descriptive-predictive approach. Predictive approach is valuable for conducting research that aims to anticipate a specific occurrence (Panda, 2023). The study included 150 senior high school students attending in a sectarian private school in Davao City during the 2022-2023 academic year. The data was collected through simple random sampling, meaning that every member of the population had an equal chance of being selected (Taherdoost, 2016). Subsequently, predictive analysis techniques such as multiple regression analysis employed in the study were used to determine the combined identified predictors of student motivation in science. In this study, three adapted questionnaires were utilized, these are The Teacher Professional Development Student Assessment Scale (Bozkuş, 2019), 21st Century Skills Survey Instrument for High School Students (Kelley et al., 2019), and Students' Motivation Towards Science Learning (Tuan et al., 2020). The research instrument was subjected to validation from the research experts before administration. The combined result from three expert validators obtained an average of 4.33 or very good. The study used mean, pearson r and multiple linear regression and was undergone thorough ethics review.

3. Result and Discussion

3.1. Level of Perceived Teacher Professional Development

As shown in Table 1 is the level of perceived teacher professional development obtained an overall mean of 4.28 and a descriptive level of *very high* which means that always observed. The results indicate that the presence of teaching-related characteristics within the classroom environment significantly contributes to determining the extent of professional development achieved by educators. This confirms Sancar and Deryakulu's (2021) statement that teachers' professional development is crucial to improving student outcomes. This is supported by the study conducted by Whitworth and Chiu (2015), which shows that under the right conditions, professional development may help teachers be more effective and result in gains in student achievement.

Table 1. Level of Perceived Teacher Professional Development

Indicators	Mean	Descriptive Level
Orientation	4.53	Very High
Learning Environment	4.41	Very High
Configuration	4.33	Very High
Application	4.28	Very High
Management of Time	4.27	Very High
Assessment	4.17	High
Questioning	4.16	High
Teaching Modelling	4.12	High
Overall	**4.28**	**Very High**

In particular, among the eight indicators, respondents perceived that *orientation* has the highest mean score of 4.53, which means that it was always observed. This further implies that respondents agreed that they were informed about the subject's learning objective, enabling them to participate in the lesson effectively, thus making it meaningful. The result also affirms the statement of Yeager et al. (2016) that orientation helped students to see the value of the material and to believe that they could improve, which led to increased effort and better performance. This finding substantiates the idea of deLuse (2018), who suggested that the first day of class is a critical opportunity for setting the tone and expectations, which can be achieved by discussing course objectives. Further, this is in connection with the statement of Sewagegn (2020), which emphasizes the need for clear and meaningful learning objectives, which can be linked to assessment to drive student success. This is further supported by Amirzai (2021), who highlighted the role of self-efficacy and instructor support in increasing student participation.

The second highest indicator is *learning environment*, with a mean score of 4.41 or *very high*, which means it was always observed. This implies that respondents concurred their teacher consistently strives to maintain discipline in the classroom by ensuring a positive learning environment for all and has specific class rules to prevent them from engaging in disruptive activities and empowers them to make a positive influence and provide support during their lessons. Soulé and Warrick (2015) emphasized that learning environments in the 21st century should be seen as the support systems that organize the conditions in which humans learn best— systems that accommodate the unique needs of every learner and support the positive human relationships needed for effective learning. Additionally, Patrizi (2019) builds on these ideas, drawing on the OECD's Innovative Learning Environments study to highlight the need for robust, innovative learning environments that support 21st-century learners.

The third highest indicator is *configuration*, with a mean score of 4.33 or *very high*, which means it was always observed. Based on the data, the respondents agreed that their teacher starts the lesson by reviewing what they had learned before, makes them feel the beginning, development, and closing stages of the lesson, draws their attention to the essential points of the lesson, and finishes the lesson by repeating what they have learned. This finding articulates Nikitina's (2020) assertion, emphasizing the importance of involving students in the methodological organization of lessons, allowing them to take the initiative and participate in joint activities. Further, Narti et al. (2016) highlighted using structural, delivery, and learning management strategies, such as thematic learning and student progress reports, to enhance the learning experience. Additionally, Afzal and Rafiq (2022) found that supportive and concerned teachers and those who use innovative instructional techniques are more successful in enhancing student participation.

The fourth highest indicator is *application*, with a mean score of 4.28 or *very high*, which means it was always observed. The data reveals that science teachers allow students to work in small groups and provide an opportunity to apply what the students learn in the classroom. The result affirms Singh's (2020) statement that training students in effective small-group dynamics can improve learning outcomes and student behavior. Similarly, Kang (2016) pointed out the benefits of interleaved practice, suggesting that mixing different activities during practice can enhance learning. Also, Gebru (2020) emphasized the application of adult learning theories, such as small group teaching methods, can also be effective in encouraging student interaction and communication skills). The same result was also found by Wei (2018) that teachers can facilitate productive small-group talk through specific discourse moves, which can further enhance the learning experience.

The fifth highest indicator is *management of time* with a mean score of 4.27 or *very high*, which means it was always observed. This implies that teachers effectively manage time during classroom activities by starting the lesson without wasting time and ensuring the entire allocated time for a lesson is utilized thoroughly. In line with this result, Khan et al. (2016) found a positive relationship between teachers' time management techniques and their class performance, mainly through effective lesson planning. This was further supported by Sahito et al. (2016), who emphasized the impact of time management on teachers' professional lives and their students' performance. Mykhaloiko et al. (2022) underscored the need for goal setting, priority determination, and eliminating time-wasting activities in the teacher's work.

The sixth highest indicator of the teacher professional development is *assessment,* with a mean score of 4.17 or *high,* which means that it was oftentimes observed. This implies that the respondents agreed that their teachers use the proper techniques to get feedback on student learning, analyze the data to determine student needs, announce the results to students and parents, and evaluate their practices. This aligns with the study of Pellegrino et al. (2019), which highlighted the importance of assessment in promoting deeper learning. They argued that assessments should be designed to support the development of critical thinking, problem-solving, and communication skills rather than just measuring knowledge acquisition. Van der Kleij (2022) also proposed a student-centered perspective on assessment and feedback, emphasizing the need for sustainable practices that enhance student learning outcomes.

The seventh highest indicator of the teacher professional development is *questioning,* with a mean score of 4.16 or *high,* which means that it was oftentimes observed. In terms of questioning, the data revealed that Science teachers are perceived to be able to create various types of questions at the appropriate difficulty level for the students to participate in the class. It indicates that the Science teacher guides students to find the correct answer when they answer the questions incorrectly and resolves their difficulty understanding them. This finding of the study supported the idea of Shanmugavelu et al. (2020) that questioning techniques will increase motivation and promote students' ability to think critically and creatively. Further, Rahayu et al. (2019) highlighted the role of teachers' questions in guiding students to build knowledge and develop explanations, focusing on explication, scientific practice, explanation, and science concept questions.

The lowest indicator, albeit still high, of the teacher professional development is *teaching modeling,* with a mean score of 4.12 or *high,* which means that it was oftentimes observed. Regarding teaching modeling, the respondents agreed that their teacher encouraged them to find solutions for the problems they faced in science class and effectively use approaches to facilitate their understanding and application of scientific ideas. In line with this, Bostic et al. (2016) provided evidence of the positive impact of a problem-solving-based instructional approach on students' problem-solving performance. Moreover, Masithoh (2018) highlighted the importance of a scientific approach to teaching, which can help students develop scientific attitudes and problem-solving skills. Sidek et al. (2020) further emphasized the crucial role of teachers in fostering scientific creativity, suggesting various pedagogical approaches and strategies.

3.2. Level of 21st Century Skills of Students

As shown in Table 2 is the level of 21st Century Skills of Students which gained an overall mean of 4.25, or very high this means that the items is always manifested among senior high school students. This suggests that learners acknowledge their acquisition of 21st-century competencies, employing these skills effectively within the context of a science classroom environment. This substantiates the series of studies from various authors (Mayıs, 2018; Nurlenasari et al., 2019; Diocos, 2023) who consistently found that secondary school students possess high levels of 21st-century skills, particularly in the areas of critical thinking, creativity, collaboration, and communication. These skills are crucial for their academic success, and the findings suggest that students are well-prepared in these areas.

Table 2. Level of 21st Century Skills of Students

Indicators	Mean	Descriptive Level
Collaboration	4.49	Very High
Communication	4.25	Very High
Creativity	4.23	Very High
Critical Thinking	4.02	High
Overall	**4.25**	**Very High**

Among the four indicators of 21st-century skills, as perceived by students, respondents perceived that *collaboration* has the highest mean score of 4.49. Based on the data, collaboration gets a mean score of 4.49 or *very high*, meaning it was always manifested. This suggests that students could collaborate by adhering to group guidelines, recognizing and valuing diverse points of view, and, most significantly, providing support to their peers in their academic endeavors when required. This finding substantiates the idea of Erdoğan (2019) that practicing collaboration helps students understand how to address a problem, pitch solutions, and decide the best course of action. It is also helpful for them to learn that other people do not always have the same ideas that they do. Also, Palma and Nadiasari (2022) pointed out that the ability to collaborate is one of the 21st Century Competencies. Further, Raden and Lampung (2021) observed high collaboration skills in science learning, particularly in group discussions and assignment responsibility.

The second highest indicator of 21st-century skills as perceived by students is *communication*, with a mean score of 4.25 or *very high*, which means that it was always manifested. Students exhibited confidence in their ability to arrange information coherently, present it concisely, logically, and clearly, communicate contrasting and opposing viewpoints, and employ suitable nonverbal communication while presenting and answering questions concisely and lucidly. Varona (2020) found a significant correlation between communication skills and academic performance, suggesting that these skills are a key predictor of success. Raptou et al. (2017) underscored the role of communication skills in creating modern, democratic, and intercultural schools. However, Thu (2021) identified a need for more confidence and proficiency in English communication among high school graduates, indicating a potential area for improvement.

The third highest indicator of 21st-century skills as perceived by students is *creativity*, with a mean score of 4.23 or *very high*, which means that it was always manifested. This implies that students possess the capacity to apply their knowledge and insights to diverse situations, identify and access information and inspiration unavailable to others, harness their creativity and imagination, foster a range of innovative viewpoints, and utilize creativity to address scientific challenges and drive innovation. A study by Iskandar et al. (2020) found that STEM-based learning significantly improved these creative thinking skills. This can be associated with the studies of Ritter et al. (2020) and Ritter and Mostert (2017), which reported positive outcomes from creativity training programs, with improvements in ideation skills, cognitive flexibility, and creative performance measures. Ahmadi and Besançon (2017) highlighted the potential for creativity to enhance other 21st-century skills, such as critical thinking and collaboration, in the classroom.

The lowest indicator, though still *high*, is *critical thinking*, with a mean score of 4.02 or high, which means that it was oftentimes manifested. The findings of the study suggest that students who possess a strong understanding of the subject matter can accurately identify and clarify the critical components of a science inquiry question, evaluate the evidence and reasoning presented in support of an argument, formulate additional questions further to explore the needs and concerns of intended audiences and engage in critical thinking by asking probing and insightful questions. Also, Permana et al. (2019) emphasized the importance of academic ability, mastering concepts, and analytical skills in developing students' critical thinking skills. However, Saputri (2018) found that while students demonstrated good critical thinking skills in evaluation and self-regulation, there was room for improvement in interpretation, analysis, conclusion, and explanation. This is supported by Febri et al. (2019), who also highlighted the need to explore ways to enhance students' critical thinking skills further in science learning.

3.3. Level of Students Motivation in Science

Shown in Table 3 is the level of Students Motivation in Science which obtained an overall mean of 3.98 and a descriptive level of *high,* this means that the item is oftentimes manifested among senior high school students. Students often showed a strong drive and enthusiasm for science-related activities and learning experiences. This implies a positive attitude towards engaging with scientific concepts, which could lead to increased participation and better academic performance. Furthermore, the result also implies that there may be other factors that influence students' motivation towards science. This substantiates the series of studies from various authors that identify a range of factors that have been found to influence students' motivation in science (Shin et al., 2016; Bullock, 2017; Zhang & Bae, 2020). Bullock (2017) identified significant factors in teacher-student relationships, student-peer relationships, teacher expectations, instructional delivery, and teacher demographics. Zhang and Bae (2020) highlighted the influence of the Expectancy-Value Theory on science achievement. Shin et al. (2016) emphasized the role of career motivation in science learning.

Table 3. Level of Students Motivation in Science

Indicators	Mean	Descriptive Level
Achievement Goal	4.30	Very High
Science Learning Values	4.28	Very High
Active Learning Strategies	4.19	High
Learning Environment Stimulation	3.98	High
Self-efficacy	3.83	High
Performance Goal	3.29	Moderate
Overall	**3.98**	**High**

In particular, among the six indicators of students' motivation in science, respondents perceived that *achievement goal* has the highest mean score of 4.30. Based on the data result, the *achievement goal* gets a mean score of 4.30 or *very high*, which means that it was always manifested. This implies that students experience a sense of fulfillment when they achieve a high score on a test, have confidence in their understanding of science class content, successfully solve challenging problems, and have their ideas accepted by the teacher. This finding substantiates the idea of Skinner et al. (2017) that students' appraisals of competence, autonomy, and relatedness fuel their intrinsic motivation. Shin et al. (2016) highlighted the role of career motivation in science learning, mainly focusing on its influence on STEM track choice. Moreover, Velayutham and Aldridge (2013) identified specific features of the classroom environment, such as student cohesiveness and task orientation, as influential predictors of motivation and self-regulation in science learning.

The second highest indicator of the students' motivation in science is *science learning values*, with a mean score of 4.28 or *very high*, which means that it was always manifested. This implies that respondents concurred that acquiring scientific knowledge is crucial due to its practical application in everyday life and its ability to stimulate critical thinking. They emphasized the significance of learning science to tackle problems and satisfy their curiosity. Various studies explored the values and attitudes that influence science learning among students. Khongkhao and Wongsongja (2020) found that students at Suan Sunandha Rajabhat University in Thailand had a high level of science learning attitude, particularly emphasizing utilizing science. This was further supported by Ocak et al. (2021), who identified a positive correlation between students' scientific attitudes and their inquiry learning skills. Wang and Liou (2017) highlighted the importance of motivational beliefs, such as self-concept, intrinsic value, and utility value, in predicting science achievement, with a positive school contextual effect on self-concept.

The third highest indicator of the students' motivation in science is *active learning strategies,* with a mean score of 4.19 or *high,* which means that it was oftentimes manifested. The idea is further conveyed that students voluntarily align new scientific ideas with their previous experiences and actively seek support from educators or peers to gain clarity. They demonstrate determination in linking and comprehending scientific concepts, even when confronted with initial bewilderment or inconsistencies with their existing knowledge. Matuk and Linn (2018) found that students who collected diverse ideas during science inquiry tended to produce higher quality explanations, suggesting that they actively seek. Benedict-Chambers et al. (2017) highlighted the role of teachers in guiding students toward sensemaking, mainly through the use of specific questioning practices that integrate scientific practices with content.

The fourth highest indicator of the students' motivation in science is *learning environment stimulation,* with a mean score of 3.98 or *high,* which means that it was oftentimes manifested. This implies that students exhibit a willingness to engage actively in the science classroom, driven by the dynamic and captivating nature of the content, the employment of diverse instructional strategies by the teacher, a perceived absence of undue academic pressure, personalized attention from the teacher, the inherent challenge presented, and active involvement in class discussions. In line with this, Ghaffar et al. (2019) and Schulze and Heerden (2015) emphasized teachers' crucial role in creating a motivating learning environment, with Ghaffar specifically highlighting the positive effect of teachers' self-efficacy. Yildirim (2020) and Tas (2016) further underscored the importance of the learning environment, with Yildirim's study demonstrating the positive impact of out-of-school learning environments on science learning motivation, and Tas's study showing the positive influence of perceived classroom learning environment on student engagement in science.

The fifth highest indicator of the students' motivation in science is *self-efficacy,* with a mean score of 3.83 or *high,* which means that it was oftentimes manifested. This implies that students demonstrate self-assurance in understanding intricate scientific concepts, express confidence in their examination outcomes, approach challenging tasks with determination, prioritize independent problem-solving in scientific activities, and perceive difficult lessons as avenues for personal growth, actively pursuing comprehensive comprehension. Kartimi et al. (2021) suggested that students' self-efficacy can be enhanced by familiarizing them with success in science learning. Lin (2021) further emphasized the importance of promoting students' science learning self-efficacy from various aspects to improve their engagement in science learning.

The lowest indicator of the students' motivation in science is *performance goal*, with a mean score of 3.29 or *moderate*, which means that it was sometimes manifested. This suggests that other factors affecting students' motivation in science other than participating in science class to get a good grade or outperforming peers and seeking recognition for their intelligence or attention from the teacher may not consistently prioritize these performance-driven motivations. Findings collectively suggest that combining intrinsic and extrinsic motivation, a supportive learning environment, and effective teaching practices can enhance students' performance goals in science learning (Libao et al., 2016; Kahraman, 2022; Ghaffar et al., 2019). Libao et al. (2016) found a positive relationship between extrinsic motivation and academic performance. Kahraman (2022) identified a reciprocal and positive relationship between students' perceptions of the science learning environment and their achievement goals. Ghaffar et al. (2019) highlighted the significant impact of teachers' self-efficacy on students' performance goals and science learning value.

3.4. Significance on the Relationship between Perceived Teacher Professional Development and Students Motivation in Science

Presented in Table 4 is the significance of the relationship between perceived teacher professional development and students' motivation in science, which obtained a p-value of .000, which is lower than the significance level. This implies that perceived teacher professional development and students' motivation in science are significantly correlated, leading to rejecting the null hypothesis. Further, the result garnered an r-value of .463, indicating a positive and moderate relationship. It explains that for every change in Teacher Professional Development, there is also reasonable development and improvement in Students' Motivation in Science. This suggests that educators are required to introspect regarding their pedagogical traits, thereby evaluating their methodologies within the classroom context. This evaluation is particularly crucial at the initiation and conclusion of classes to ascertain that students remain engaged and motivated throughout the entirety of the science instruction period.

In the study conducted by Leng et al. (2021) and Smart (2014), both found a positive correlation between teacher-student interactions and student motivation, with Leng emphasizing the role of teacher communication behavior and Smart focusing on the impact of teacher interpersonal behaviors. Additionally, Fischer et al. (2018) and Marth et al. (2018) further supported these findings, with Fischer et al. (2018) highlighting the influence of professional development on teachers' classroom practices and Marth et al. (2018) underscoring the importance of motivation in the context of inquiry-based science education.

Table 4. Significance on the Relationship between Perceived Teacher Professional Development and Students Motivation in Science

	Students Motivation in Science			
	r	p-value	Decision on H_o	Interpretation
Perceived Teacher Professional Development	0.463	0.000	Reject	moderate correlation

Moreover, Alzouebi (2019) presented a model for effective science teacher professional development that can positively influence student learning. Zhang and Bae (2020) further support this, identifying motivational factors significantly impacting student science achievement. Finally, Patall et al. (2019) highlighted the importance of agentic engagement in science classrooms, suggesting it can increase student motivation and engagement.

3.5. Significance on the Relationship between 21st Century Skills and Students Motivation in Science

Table 5 reflects the significant relationship between 21st Century Skills and Students Motivation in Science with an overall p-value of 0.000, the correlation is significant at a 0.05 level of significance, thus the null hypothesis is rejected. It shows that there is a significantly strong direct correlation between the two variables. The correlation coefficient of r = 0.672 indicates a strong positive relationship between the variables. The positive sign of the correlation coefficient indicates a direct relationship, meaning that the variables move in the same direction. This means that for every change in the independent variable, there is an equivalent high changes in the dependent variable.

Table 5. Significance on the Relationship between 21st Century Skills and Students Motivation in Science

	Students Motivation in Science			
	r	p-value	Decision on H_o	Interpretation
21st Century Skills	0.672	0.000	Reject	significant

Moreover, looking at the relationship between the two variables, a high degree of relationship between perceived 21st-century skills and students' motivation in science exists, as evidenced by the r-value of .672. This suggests that fostering and developing 21st Century Skills in students can substantially improve their motivation within the science domain, highlighting the critical role of contemporary skills in shaping students' engagement and enthusiasm for scientific learning. Turiman et al. (2019) found a high level of 21st-century skills mastery among science foundation students, with no significant differences based on gender or former school location. Libao et al. (2016) identified a positive correlation between students' motivation and academic performance in science, particularly regarding extrinsic motivation. In addition, Haryanto and Arty (2019) highlighted the role of contextual teaching and learning in improving high-order thinking skills and self-efficacy, which can enhance student motivation in science learning. However, Kalemkuş (2021) highlighted the need for a more balanced distribution of 21st-century skills in the science curriculum, focusing on critical thinking, problem-solving, communication, creativity, and innovation.

3.6. Significance on the Combined Influence of Perceived Teacher Professional Development and 21st Century Skills on Students Motivation in Science

Presented in table 6 is the regression model showing the combined influence of variables of perceived teacher professional development and 21st-century skills on students' motivation in science. The analysis illustrates that the overall p-value of 0.000 with the corresponding F-value of 61.447 means that teacher professional development and 21st-century skills as variables have a combined significant influence on students' motivation in

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science. Therefore, the null hypothesis is rejected. Further, the two independent variables are treated as one factor that significantly influences the dependent variable. It means that it is not necessary to mean that the two independent variables should influence the dependent variable considering the F-value as it implies that at least one of the predictors identified is significantly predicting.

Table 6. Significance on the Combined Influence of Perceived Teacher Professional Development and 21st Century Skills on Students Motivation in Science

	Students Motivation in Science						
	Unstandardized Coefficients		**Standardized Coefficients**				
Independent Variables	**B**	**Std. Error**	**Beta**	**t**	**Sig.**	**Decision on H_o**	**Interpretation**
Perceived Teacher Professional Development	.116	0.111	0.081	1.047	0.297	Failed to reject	Not significant
Students Motivation in Science	.755	0.094	0.622	8.071	0.000	Reject	Significant

$R = .675$; $R^2 = .455$; F-value = 61.447; p-value = 0.000

The standard coefficient of the 21st-century skills variable has the highest Beta of .622, which implies that 21st-century skills as a variable have the highest degree of influence on students' motivation in science. At the same time, the teacher's professional development has a standardized coefficient beta of 0.081. Looking at the t-value, 21st-century skills as a variable have the highest, and the variable teacher professional development has the lowest. This means that there is greater evidence against the null hypothesis. The larger the absolute value of the t-value, the smaller the p-value, and the greater the evidence against the null hypothesis. Analysing the data in Table 6 bit by bit, these explain that the combined variables, namely teacher professional development and 21st-century skills, contributed significantly to students' motivation in science. These are manifested in the regression analysis results of 45.5% of the variance, which is explained by the two variables as indicated by the R2 value of 0.455. This also signifies that 54.5% of the variation in the students' motivation in science is attributed to other factors.

In a study conducted by Ghaffar et al. (2019) and Velayutham and Aldridge (2013), both found that teachers' self-efficacy and the psychosocial classroom environment significantly influence students' motivation and self-regulation in science learning. Investing in teacher training and support can positively impact student motivation. Furthermore, Leong et al. (2018) found that intrinsic motivation is critical to students' science achievement, indicating that fostering a love for science can lead to better academic outcomes. Further, Teachers can increase students' motivation to learn by supporting their autonomy, relevance, relatedness, competence, and interests (Johnson, 2017). Teachers can also influence their students' motivation through their instructional practices by encouraging the students and by acting as role models (Fortus & Touitou, 2021)

On the other hand, studies on 21st-century skills and student motivation have revealed a strong relationship between the two. Talmi et al. (2018) found that participation in projects that require these skills can enhance students' intrinsic motivation. Sedden and Clark (2016) further emphasized the role of educators in motivating students, highlighting the importance of high expectations, an open atmosphere, and multidimensional teaching strategies. However, Varona (2020) noted that while 21st-century skills are essential, only communication skills showed a significant correlation with academic performance. This suggests that while these skills can enhance motivation, their impact on academic performance may vary.

4. Conclusion

This study concludes that perceived teacher professional development and 21st-century skills have a significant combined influence on students' motivation in science. However, looking individually, only 21st-century skills significantly influence students' motivation in science, while the perceived teacher professional development has no significant influence on students' motivation in science. Therefore, the conclusion of this study does not fully support the theory of Self-determination, which emphasizes that perceived teacher professional development is an external factor and 21st-century skills as an internal element that influences students' motivation in science because the research shows that only one independent variable has a significant influence on students' motivation in science.

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