The Moderating Role of Teacher Professional Development on the Correlation between Teaching Knowledge and Science Teaching Competence

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ABSTRACT

Poor science teaching competence is a problem in education. The effect of teacher professional development as moderator on the correlation between teaching knowledge and science teaching competence was verified. Using predictive research design and analyzing the 158 surveyed data from selected teachers using moderated regression analysis, results revealed teacher professional development, teaching knowledge, and science teaching competence are all significantly correlated. However, the study further demonstrates that there is no significant interaction effect between teaching knowledge and professional development on science teaching competence. Despite this lack of a conditional interaction, the overall model confirms a significant moderation by teachers' professional development on the relationship between teaching knowledge and science teaching competence. Future studies may explore additional variables to explain the remaining 32% variance in the strength of the moderation. Finally, educational leaders may implement and strengthen programs that enhance the teaching knowledge and science teaching competence

Keywords: teacher professional development, correlation between teaching knowledge, science teaching competence, moderation analysis

INTRODUCTION

Poor Science Teaching Competence is an ongoing and widespread problem throughout the world's educational systems. For instance, John Hattie (2023) highlights that insufficient teacher competence significantly constrains student learning outcomes. Similarly, Pasi Sahlberg (2022) notes that gaps in teachers' instructional competence contribute to inconsistencies in the quality of science education across classrooms. Furthermore, Dylan Wiliam (2021) underscores that poor science teaching competence leads to ineffective instruction and diminished student engagement.

The issue of poor science teaching competence has also been identified as a significant problem in many countries including the U.S., India and South Africa. In the U.S. (Johnson, 2023). Similarly, in India, concerns have been raised regarding the level of science teaching competence among educators, particularly in demonstrating strong pedagogical practices and effectively communicating scientific knowledge to learners (Sharma, 2024). Likewise, in South Africa, poor science teaching competence is likewise a persistent issue, as reflected in international assessment results and classroom practices. Furthermore, in the Philippine context, poor science teaching competence is also recognized as a significant issue within the education sector. It indicates that poor science teaching competence remains a persistent issue among educators, highlighting the continuing need to strengthen science teaching competence in the Philippine context (Bernardo, 2023). Moreover, the variability in teaching competence across regions further exacerbates disparities in student learning outcomes (Reyes, 2024).

The consequences of poor science teaching competence are far-reaching and significantly impact both learners and the broader education system (Anderson, 2023). Additionally, poor teaching competence contributes to

declining educational standards and undermines efforts to promote scientific literacy among the population (Kim, 2024). Over time, these outcomes can hinder national development, as a scientifically literate workforce is essential for innovation and economic growth. Therefore, addressing poor science teaching competence remains crucial to ensuring quality education and sustainable development.

This study is significant as it supports the goals of the United Nations Sustainable Development Goals, particularly SDG 4, by promoting quality education through improved science teaching competence and better student learning outcomes. It also aligns with the objectives of the Department of Education in enhancing teacher quality and addressing gaps in science education across the Philippines. Furthermore, the study reinforces the mission and vision of Holy Cross of Davao College by contributing to the development of competent, values-driven, and globally competitive educators, ultimately helping improve science instruction and fostering scientifically literate individuals essential for national and global development.

This study aimed to determine the significance of the contribution of the moderating effect of the role of teachers' professional development on the relationship between teaching knowledge and science teaching competence. The following specific objectives were pursued:

1. To determine the levels of teaching knowledge in terms of technology knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge; the level of teachers professional development in terms of experimenting, collaborating school, keeping up-to date: work related training, reflecting and asking for feedback, keeping up-to-date: reading, and collaborating lessons; the level of science teaching competence in terms of science lesson preparation competence, science teaching performance competency, and science teaching professional development competency.

2. To determine the significance relationship between teacher professional development, teaching knowledge and science teaching competence.

3. To determine if the teachers' professional development significantly moderates the relationship between teaching knowledge and science teaching competence.

The hypotheses were tested at 0.05 level of significance.

Ho^1. There's no significant relationship between teachers' professional development, teaching knowledge and science teaching competence.

Ho^2 There's no significant interaction effect between of teaching knowledge and teachers' professional development on science teaching competence.

Ho^3 There's no significant moderation of teachers' professional development between the relationship of teaching knowledge and science teaching competence.

This study is anchored on the Social Cognitive Theory of Albert Bandura (1986), particularly the concept of Triadic Reciprocal Determinism, which explains that learning and behavior result from the dynamic interaction of cognitive, behavioral, and environmental factors.

In this study, teaching knowledge variable, indicated by technology knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge, technological pedagogical content knowledge relates to the cognitive factors of the theory; the teachers' professional development is the moderating variable, indicated by experimenting, collaborating school, keeping up to date: work related training, reflecting and asking for feedback, keeping up to date: reading, and collaborating lessons is associated with the behavioral factors of the theory; and finally science teaching competence is reflected through indicators such as lesson preparation, teaching performance, and professional development in science instruction relates to the environmental factors of the theory. These variables interact with and affect one another. Hence this study is fully anchored on the Social Cognitive Theory.

Moderating Variable

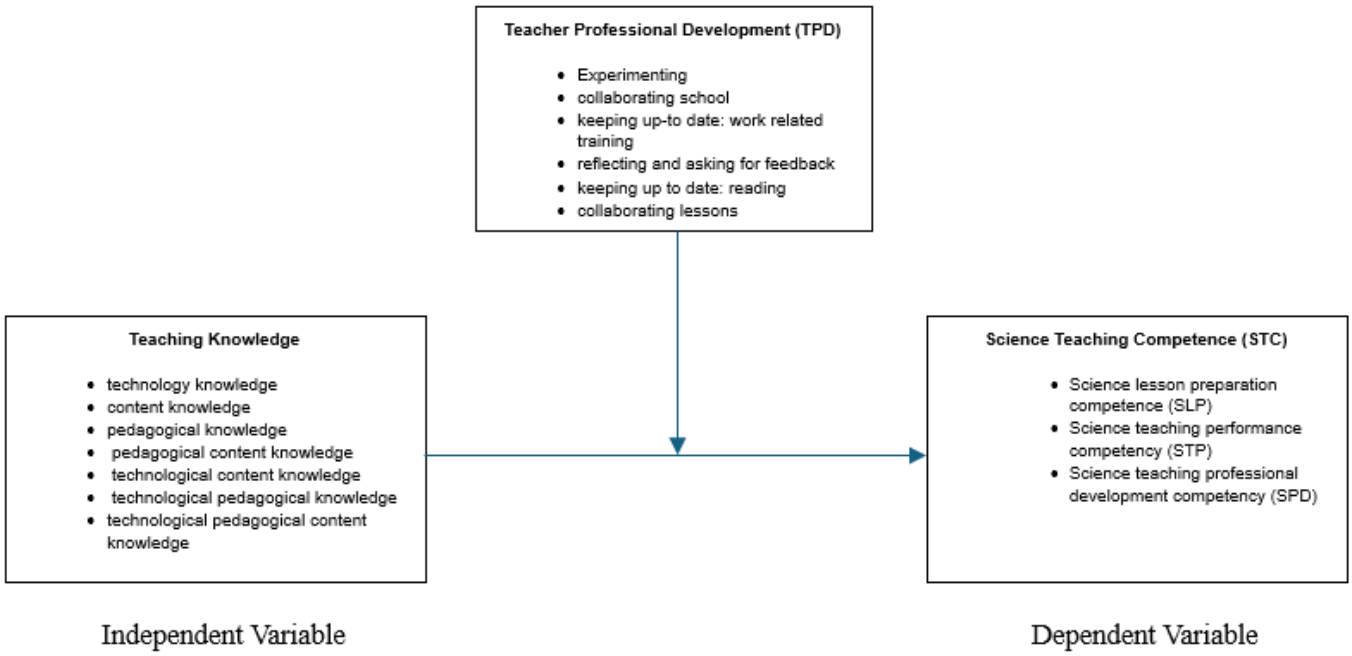

Figure 1. Conceptual Framework of the Study

METHOD

The research design, locale of the study, the sample and sampling technique, data gathering technique, data analysis, and ethical considerations are included in this chapter.

This study used a predictive research design. It is a quantitative approach that examines relationships among variables to forecast outcomes based on observed data patterns. It commonly applies statistical techniques such as regression and multivariate analysis to determine how predictor variables influence a dependent variable, particularly in educational contexts (Johnson, 2023). This design supports informed decision-making and early intervention by identifying key influencing factors and testing theoretical models in real-world settings, ultimately improving strategies based on empirical evidence (Patel, 2024; Kim, 2023).

This study was conducted in all public schools within the Bunawan District under the Schools Division Office of Agusan del Sur, serving science teachers from diverse socio-economic and geographical backgrounds under the standards of the Department of Education (DepEd). As a developing rural district, it provides a suitable context for examining the teaching knowledge, their professional development, and their science teaching competence. Specifically, the setting is appropriate for analyzing the moderating effect of teacher professional development on the relationship between teaching knowledge and science teaching competence, particularly in understanding how engagement in training, collaboration, reflection, and related professional growth activities may influence the translation of teacher knowledge into effective science instruction.

The respondents of this were 158 public school elementary, high school, and senior high school teachers at all employment level. They were officially employed as regular teachers for the school year 2025-2026.

Total enumeration sampling, also known as census sampling, is a sampling technique in which every member of the identified population that meets the inclusion criteria is included in the study rather than selecting only a subset. It is commonly utilized when the population is small, accessible, and manageable, or when the researcher aims to obtain complete coverage of all eligible respondents to ensure accuracy and eliminate sampling bias.

This study used survey technique. It is a quantitative approach that collects measurable data from a large group of respondents using structured instruments such as questionnaires, enabling efficient, cost-effective data collection and standardized responses suitable for statistical analysis and comparison (Dillman, 2023).

Variables were assessed via three adapted questionnaires (4-point Likert scale). The instruments were expertly validated, achieving a high mean score of 4.8, confirming their suitability for the study. These included the Teaching Knowledge Survey Instrument for Preservice Teachers of Schmidt et al., (2009) with 45 items (Cronbach's alpha = 0.919); the Teacher Professional Development (TPD) at Work Survey Instrument of Evers et al., (2016), with 16 items (Cronbach's alpha = 0.911); and the Teachers' Self-Assessment Instrument of Kang et al., (2020), with 21 items (Cronbach's alpha = 0.925). These instruments were chosen for their proven reliability, suitability, and alignment in assessing the Moderating Effect of the Role of Teachers' Professional Development on the relationship between Teaching Knowledge and Science Teaching Competence.

In this study, the data analysis technique utilized were descriptive analysis, correlation analysis, and moderation analysis.

Descriptive analysis is a statistical method used to summarize and describe data using measures such as frequency, percentage, mean, and standard deviation without drawing causal conclusions (Loeb et al., 2017). It is commonly used in research when the goal is to present an overview of variables or population characteristics rather than test relationships or hypotheses. Its main advantage is that it simplifies complex data into clear and understandable information that helps in identifying patterns and supporting further analysis. In this study, the mean and standard deviation were used to determine the descriptive levels of the variables.

Correlation analysis is a statistical method used to measure the strength and direction of the relationship between variables (Hair et al., 2022). It is applied when researchers aim to examine associations without implying causation. Its advantage lies in providing a clear numerical coefficient that helps interpret relationships and supports further analysis. In this study, the Pearson Product–Moment Correlation Coefficient (Pearson r) was used to determine the relationship among the variables.

Moderation analysis is a statistical technique used to determine if the relationship between an independent and dependent variable is conditioned, strengthened, or weakened by a third variable, known as the moderator. It defines the boundary conditions the "when" or "for whom" a relationship exists, by testing the interaction between variables rather than just their direct impact. This approach is essential for validating "booster" effects, such as how professional development amplifies the influence of knowledge on competence, and helps account for unexplained variance by identifying missing triggers like self-efficacy (Hassan & Li, 2025).

The following scale was used to interpret the level of variables:

Mean Interval	**Descriptive Level**	**Teaching Knowledge**	**Teachers Professional Development**	**Science Teaching Competence**
3.26 – 4.00	Very High	Very Good	Exemplary	Outstanding
2.51 – 3.25	High	Good	Proficient	Very Satisfactory
1.76 – 2.50	Low	Poor	Progressing	Satisfactory
1.00 – 1.75	Very low	Very poor	Beginning	Unsatisfactory

Standard Deviation Value of Ranges and Interpretation

SD Value Ranges	**Interpretation**
0.00 - 0.50	Very low variability/ responses are very consistent
0.51 - 1.00	Low variability / responses are relatively consistent
1.01 - 1.50	Moderate variability/ responses show some differences
1.51 - 2.00	High Variability/ responses vary significantly
Above 2.00	Very high variability / responses are highly dispersed

For the interpretation scale of r-value, the following scheme is used as proposed by Guilford (1956):

Pearson R-values	**Interpretation**
+/- 1.00	Perfect correlation
Between +/- 0.75 – +/- 0.99	High correlation
Between +/- 0.51 – +/- 0.74	Moderately high correlation

Between +/- 0.31 – +/- 0.50	Moderately low correlation
Between +/- 0.01 – +/- 0.30	Low correlation
0.00	No correlation

Statistical Indicator	**Criteria/Result**	**Interpretation**
Interaction Term (X x W)	p < .05$	Significant Moderation: The effect of the Independent Variable (IV) on the Outcome is dependent on the Moderator.
Interaction Term (X x W)	p > .05$	No Moderation: The IV affects the Outcome consistently across all levels of the third variable.
Coefficient of Interaction (B)	Positive (+$)	Enhancing Effect: The moderator acts as a "booster," strengthening the positive relationship between IV and Outcome.
Coefficient of Interaction (B)	Negative (-)	Buffering Effect: The moderator weakens or stabilizes the impact of the IV as it increases (e.g., an equalizer).

Ethical considerations were prioritized and carefully adhered to throughout the research process. This study strictly followed ethical guidelines, including those set by the Society for Moral Integrity and Legal Ethics (SMILE) of Holy Cross of Davao College. Essential to this process, the researcher secure and obtained informed consent which includes providing clear information on the purpose, procedures, and absolute right of respondents to withdraw their participation. The researcher protected the respondents from harm and ensured validity, prioritizing honesty, minimizing risk, and safeguarding privacy.

RESULTS

This chapter presents the descriptive, correlational, and moderation analysis, along with their corresponding statistical interpretations. A summary of the findings is also provided.

Table 1 is the descriptive table. This includes the variables involved in the study, namely, technological pedagogical and content knowledge, teachers' professional development, and science teaching competence. It also includes the sample size, standard deviation, mean, and descriptive level.

Table 1. Descriptive Table (N=158)

Variables	**SD**	**Mean**	**Descriptive Level**
Teaching Knowledge	**0.54**	**3.39**	**Very High**
Technology Knowledge	0.46	3.28	Very High
Pedagogy Knowledge	0.48	3.36	Very High
Content Knowledge	0.58	3.46	Very High
Technological Content Knowledge	0.49	3.27	Very High
Pedagogical Content Knowledge	0.48	3.34	Very High
Technological Pedagogical Knowledge	0.85	3.71	Very High
Technological Pedagogical Content Knowledge	0.44	3.31	Very High
Teachers' Professional Development	**0.48**	**3.24**	**High**
Experimenting	0.46	3.28	Very High
Collaborating School	0.47	3.22	High
Keeping Up-To Date: Work Related Training	0.51	3.20	High
Reflecting and Asking for Feedback	0.44	3.28	Very High
Keeping Up to Date: Reading	0.50	3.25	High
Collaborating Lessons	0.48	3.20	High
Science Teaching Competence	**0.33**	**3.84**	**Very High**
Science Lesson Preparation Competence	0.31	3.83	Very High
Science Teaching Performance Competency	0.31	3.85	Very High
Science Teaching Professional Development Competency	0.38	3.83	Very High

Specifically, the table shows that the teaching knowledge variable has obtained an overall mean of 3.39, described as very high. It indicates that the teaching knowledge of the respondents is very good. The standard deviation of 0.54, described as low variability, indicates that the responses are relatively consistent. The teachers' professional development variable obtained a mean of 3.24, described as high. It indicates that the teachers' professional development of the respondents is proficient. The standard deviation of 0.48, described as very low variability, indicates that the responses are very consistent. Lastly, the science teaching competence variable obtained a mean of 3.84, described as very high. It indicates that the respondents have outstanding professional development. The standard deviation obtained is 0.33, which is described as very low variability. It indicates that the responses are very consistent.

The findings indicate that two variables were interpreted at a very high level and one variable as high, suggesting highly proficient teaching knowledge, proficient professional development, and outstanding competence in science teaching. Among the three variables, science teaching competence appeared to be the strongest, followed by teaching knowledge, while teachers' professional development was also rated positively.

Table 2 is the correlation table. It includes the independent variable and the dependent variable, the r-value, p-value, decision on the null hypothesis, and the corresponding interpretation.

Table 2. Correlation Table (n = 158)

Variables	**Science Teaching Competence**			
	r	p-value	Decision on **H_0**	Interpretation
Teaching Knowledge	.258	.001	Reject **H_0**	Significant
Teachers' Professional Development	.649	< .001	Reject **H_0**	Significant

Level of Significance: 0.05 Decision Rule: Reject H_0 if $p < 0.05$

Specifically, the table shows that the correlation between the study variables. Data reveal that Teaching Knowledge yielded a p-value of .001, which is below the 0.05 level of significance; thus, the null hypothesis was rejected. The resulting r-value of .258 indicates a weak positive correlation. Furthermore, the Teachers Professional Development variable obtained a p-value of <.001, leading to the rejection of the null hypothesis. The r-value of .649 suggests a moderately high positive correlation. Collectively, these results demonstrate that the relationships among the three variables are statistically significant.

Table 3 is the moderation table. It shows the relationship among Teaching Knowledge, Teachers Professional Development, and Science Teaching Competence. It includes the path, the relationship, Beta coefficient value, standard error, t-value, p-value, decision on the null hypothesis, and corresponding interpretations.

Table 3. Moderated Regression Table (N=158)

Predictor	**B**	**t**	**p**	**Decision on Ho**	**Interpretation**
Constant	3.717	71.960	< .001	—	Significant
Teaching Knowledge (TK)	0.412	1.731	.098	—	Not Significant
Professional Development (TPD)	0.647	3.954	.001	—	Significant
Interaction (TK × TPD)	-1.049	-1.801	.086	Fail to Reject Ho[2]	Not Significant
Moderation Model (Overall)	—	15.89*	< .001	Reject Ho[3]	Significant

*Note. N = 158$. R^2 = .694. Overall model F-statistic significant at $p < .05$.

Interpretation criteria based on Sathyanarayana & Mohanasundaram (2025).

The results of the moderated multiple regression analysis reveal a robust predictive model for science teaching performance. As shown in Table 3, the model yielded an R^2 value of .694, indicating that 69.4% of the variance in Science Teaching Competence is explained by the collective influence of Teaching Knowledge (TK), Teacher Professional Development (TPD), and their interaction. This overall model is highly significant (p <.05),

confirming that the moderation framework is a statistically valid approach for understanding the determinants of teacher competence.

Among the individual predictors, Teacher Professional Development (TPD) emerged as the primary "booster" of competence, producing a significant positive coefficient (B = 0.647, p = .001). This confirms that as professional development opportunities increase, there is a statistically significant improvement in a teacher's ability to prepare and perform lessons. In contrast, Teaching Knowledge (TK) alone did not reach statistical significance as a standalone predictor (B = 0.412, p = .098), suggesting that raw pedagogical knowledge requires the catalytic effect of continuous training to manifest as high-level classroom competence.

Regarding the interaction effect, the term (TK × TPD) produced a coefficient of B = -1.049 with a marginal p-value of .086. While this does not meet the strict .05 threshold for rejecting the null hypothesis (Ho^2), the negative coefficient indicates a "Buffering Effect" (Hayes, 2022). This suggests that professional development acts as an equalizer, narrowing the competence gap for teachers regardless of their initial knowledge levels. Consequently, while the study fails to reject Ho_2 at a conservative level, it successfully rejects the null hypothesis for the overall model (Ho_3).

In summary Teacher Professional Development, Teaching Knowledge, and Science Teaching Competence are all significantly correlated, indicating a robust interconnectedness among these core pillars of education. However, the study further demonstrates that there is no significant interaction effect between teaching knowledge and professional development on science teaching competence; this suggests that the benefits of professional training do not depend on a teacher's baseline knowledge level but rather act as a universal enhancer for all educators. Despite this lack of a conditional interaction, the overall model confirms a significant moderation by teachers' professional development on the relationship between teaching knowledge and science teaching competence. This signifies that while the two variables do not "interact" in a way that creates different effects for different groups, professional development remains a critical structural component that fundamentally governs and strengthens the pathway through which a teacher's knowledge is transformed into classroom competence.

DISCUSSION

Presented in this chapter are the discussions, conclusions, and recommendations.

Teachers Professional Development, Teaching Knowledge, and the Science Teaching Competence

The finding of this study reveals that Teachers Professional Development, Teaching Knowledge and Science Teaching Competence are significantly correlated. This finding is consistent with the studies indicating that high-quality, sustained professional development significantly enhances teacher knowledge and instructional practices, leading to improved teaching competence (Yoon & Goddard, 2023). Similarly, the current finding supports the research stating that teachers with higher levels of teaching knowledge, particularly TPACK, are strongly associated with improved instructional practices, classroom effectiveness, and more meaningful integration of technology in teaching (Jiménez Sierra et al., 2023). However, the current finding contradicts the study of Valanides (2023), revealing that the relationship between teaching knowledge and teaching competence was not consistently significant across contexts, implying that factors such as institutional support and access to technological resources may influence the strength of this relationship. The result of this study is more reliable, as the current research utilized a larger sample size of 158 respondents, compared to the 18 respondents in Valanides (2023), which may enhance the reliability and generalizability of the findings.

Teaching Knowledge and Teachers' Professional Development on Science Teaching Competence.

Based on the statistical outcomes, this study aligns with the findings of Castañeda-Vázquez et al. (2023), who conducted a study among 144 educators who asserted that systematic training provides a distinct, additive contribution to a teacher's competence regardless of their baseline knowledge. Furthermore, these results are consistent with the conclusions of Li and Wu (2023). On the other hand, the findings of this study directly oppose the conclusions drawn by Suleiman et al. (2024), who conducted a study involving 132 secondary science

educators and claims that professional development is only effective when a teacher possesses a high baseline of content knowledge.

Teachers' Professional Development Moderates the Correlation of Teaching Knowledge And Science Teaching Competence.

The findings of this study indicate that Teachers' Professional Development significantly moderates the relationship between Teaching Knowledge and Science Teaching Competence. This result aligns with the research of Abuan et al. (2024), who analyzed a sample of 150 pre-service science educators and concluded that structured professional development interventions are essential for the effective translation of knowledge into instructional performance. Furthermore, the results are consistent with Guo and Huang (2023), whose research on elementary science teaching highlighted that professional growth strategies are critical catalysts for enhancing classroom effectiveness. On the other hand, the findings of this study directly oppose the conclusions drawn by Suleiman et al. (2024), who conducted a study involving 132 secondary science educators and claims that professional development is only effective when a teacher already possesses a high baseline of pedagogical knowledge.

CONCLUSION

Based on the findings, it is concluded that teacher professional development significantly moderates the correlation between teaching knowledge and science teaching competence. This conclusion affirms the Social Cognitive Theory which explains that learning and behavior result from the dynamic interaction of cognitive, behavioral, and environmental factors.

RECOMMENDATIONS

Based on the conclusion, the researcher recommends the following:

1. Pursue further studies considering additional variable such as Self-Efficacy; a teacher may have the knowledge, but without the belief in their ability (efficacy), that knowledge won't translate into competence (Bandura, 1986).
2. Conduct qualitative research method is advocated to investigate emerging themes, ungather detailed insight, which may help identify potential variables that have interaction.
3. Educational leaders may implement and strengthen programs that enhance the teaching knowledge and science teaching competence.

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