Content, Pedagogical, and Technological Knowledge as Predictors of Teaching Effectiveness among Mathematics Teachers

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Abstract

Ineffective teaching remains a critical concern. The significance to forecast teaching effectiveness using content knowledge, pedagogical knowledge, and technological knowledge as predictors, was examined. Using predictive design, survey technique, cluster sampling in selecting 129 teachers, and multiple linear regression in analyzing the data, it was found that the interest variable was strongly and significantly predicted, supporting the TPACK framework. Educational leaders may strengthen teacher content, pedagogical, and technological knowledge through holistic professional development programs. Future research may explore other factors extracted from qualitative approaches to further investigate the causes of teaching effectiveness.

Keywords: Content; pedagogical; technological knowledge; predictors of teaching effectiveness; mathematics teachers

1. Introduction

Ineffective teaching is a global issue (Abakunda, 2023), as teachers worldwide continue to struggle with maintaining instructional quality (Pereira et al., 2025).

In Indonesia, studies report difficulties in sustaining effective teaching practices (Abedi et al., 2024), while in Cambodia, teachers face challenges in implementing effective instruction (Rajapakse et al., 2024). Similarly, in Pakistan, ineffective teaching remains a significant problem (Rafique, 2025).

In the Philippines, several teachers continue to encounter challenges in maintaining effective teaching practices in today's dynamic learning environment (Alvarez, 2020). They also experience difficulties in implementing effective teaching strategies, which further affect instructional quality (Enriquez, 2025).In Davao City, these prevailing obstacles have significantly impacted teachers' instructional capabilities, limiting their ability to deliver effective and engaging lessons (Lauron, 2024). Moreover, teachers encounter challenges in delivering instruction that restrict their instructional methods (Rose, 2025).

Ineffective teaching negatively affects student performance and engagement, with poor instruction leading to lower learning outcomes and persistent educational inequalities (Engida & Iyasu, 2024; Sanfo & Malgoubri, 2023). Despite this, there is limited research in Davao City examining how content, pedagogical, and technological knowledge collectively influence teachers' effectiveness and student learning outcomes. Therefore, this study is undertaken to examine this issue.

2. Methodology

2.1. Research Design

This study utilized predictive research design, which involves the collection and analysis of numerical data to determine whether one or more variables can forecast an outcome variable (Creswell & Poth, 2023). The primary purpose of this design is to examine relationships among variables and assess the extent to which specific factors can influence or predict a particular outcome. It is often used when researchers aim to identify predictors of a given variable and understand how these predictors contribute to explaining variations in the outcome. One of the key advantages of this approach is that it provides empirical evidence about the likelihood of an outcome based on certain factors, which can inform decision-making, planning, and the development of interventions or strategies in various fields of research (Best & Kahn, 2023).

2.2. Locale of the Study

The study was conducted in public elementary schools within the Buhangin East District, Davao City, under the supervision of the Department of Education (DepEd)–Division of Davao City. The district was chosen because it represented a dynamic educational environment where teachers encountered diverse learners, integrated technology into instruction, and participated in professional development activities.

Buhangin East is in northern Davao City and comprises public and private schools serving urban and suburban communities. Its schools were equipped with basic ICT facilities, such as computer laboratories and internet access, supporting technology integration in classrooms. This setting embodied both the challenges and strengths of the Philippine public education system, making it highly suitable for examining the predictive power of models of content, pedagogical, and technological knowledge for teaching effectiveness.

2.3. Sample and Sampling

A total of 129 Grade 1 to Grade 6 elementary mathematics teachers from the Buhangin East District Department of Education Division of Davao City were included in this study. According to official records from Schools Division of Davao City (2025), these 129 teachers were assigned to 6 public elementary schools across the Buhangin-East District. All teachers were officially employed as regular teachers for the school year 2025-2026. Included in the study were regular elementary mathematics teachers handling Grades 1 to 6, while teachers who were substitute, temporary, part-time, or not assigned to teach mathematics during the conduct of the study were excluded.

Data was collected using a cluster sampling technique. It is a probability sampling technique in which the researcher divides the population into naturally occurring groups (called clusters), randomly selects some of these clusters, and then collects data from all members or a sample of members within the selected clusters (Creswell & Creswell, 2018). This technique is appropriate when the population is naturally grouped into clusters, allowing the researcher to focus on one cluster while still obtaining meaningful and generalizable data, particularly in geographically organized populations such as schools or districts (Simkus & Thomas, 2023).

2.4. Data Gathering Technique

The survey technique was used in gathering data. This technique involves systematically collecting information from a sample of respondents using standardized questionnaires or structured instruments to describe characteristics, opinions, attitudes, or behaviors of a population and is applied when researchers need structured primary data to generalize findings or answer specific research questions (Stockemer & Bordeleau, 2023). It offers advantages such as efficient data collection from large groups, the ability to reach diverse populations, and structured responses that support quantitative analysis and generalizability (Zimba et al., 2023).

Four adapted instruments were employed, all using a 4-point Likert-type scale. The content knowledge questionnaire, adapted from Ragma (2014), consisted of 27 items assessing teachers' mastery of mathematical concepts and problem-solving skills, with a Cronbach's alpha of 0.973, and the pedagogical competence scale included 22 items, evaluating instructional planning, classroom management, and teaching skills, with a reliability of 0.964. The technological knowledge instrument, adapted from the Teachers' Digital Competence Scale (Ergul & Tasar, 2023), contained 18 items measuring digital literacy and technology integration, with a Cronbach's alpha of 0.940. Lastly, the teaching effectiveness questionnaire, adapted from the National Council of Teachers of Mathematics (NCTM, 2014), consisted of 36 items assessing awareness and application of effective teaching practices, with a reliability of 0.984.

2.5. Data Analysis Technique

In this research, descriptive, correlation, and regression analyses were employed. Descriptive statistics were used to summarize and organize data, providing an overview of patterns, central tendencies, and variability; this was conducted using the mean and standard deviation (Bhandari, 2023). In descriptive analysis, the mean and standard deviation were employed. The mean determined the level of the variables, while the standard deviation measured the extent of variation or dispersion in the respondents' answers. Moreover, in the correlation analysis, the Pearson Product–Moment Correlation Coefficient was used to assess the strength and direction of the relationship between the variables. Ultimately, in regression analysis, multiple linear regression was utilized to examine the predictive power of content, pedagogical, and technological knowledge and teaching effectiveness, particularly through the interpretation of the Beta (β) coefficient strength.

2.6. Ethical Considerations

Respondents were fully informed about the study's objectives and methods, and of their right to withdraw at any time without consequences. Informed consent was secured before data collection, ensuring that participation remained voluntary and ethically appropriate. The study was designed to prevent harm, ensuring that participants understand their rights and can withdraw freely without consequences. The research was conducted with transparency, integrity, and respect, safeguarding participants' privacy and valuing their contributions. Ethical approval was obtained from the SMILE (Society for Moral Integrity Legal Ethics) Board, and the study was authorized by the Department of Education (DepEd). To maximize benefits, minimize risks, and uphold fairness in the research process, appropriate measures have been implemented, ensuring transparent sharing of all findings. Any potential conflicts of interest must be disclosed to maintain the integrity of the research.

3. Results and Discussions

3.1 Descriptive Analysis

Table 1 shows the descriptive statistical results of the study. Included in the table are the variables involved, content knowledge, pedagogical knowledge, technological knowledge, and teaching effectiveness, with their respective indicators. Also presented are the number of respondents, standard deviation, mean, and descriptive level.

Variables	N	Standard Deviation	Mean	Descriptive Level
Content Knowledge	**129**	**.36**	**3.27**	**Very High**
Numbers and Number Sense		*.50*	*3.39*	Very High
Measurement		*.27*	*3.09*	High
Geometry		*.46*	*3.35*	Very High
Patterns, Functions, and Algebra		*.47*	*3.26*	Very High
Data Analysis and Probability		*.47*	*3.34*	Very High
Pedagogical Knowledge	**129**	**.41**	**3.52**	**Very High**
Teaching/Facilitating Skills		*.45*	*3.55*	Very High
Guidance Skills		*.44*	*3.54*	Very High
Management Skills		*.44*	*3.50*	Very High
Evaluation Skills		*.43*	*3.51*	Very High
Technological Knowledge	**129**	***.41***	***3.40***	**Very High**
Learning-Teaching Process		*.43*	*3.42*	Very High
Selecting and Using Digital Resources		*.47*	*3.32*	Very High
Assessment		*.48*	*3.27*	Very High
Digital Technologies		*.43*	*3.28*	Very High
Ethical Use of Resources		*.42*	*3.34*	Very High
Teaching Effectiveness	**129**	***.36***	***3.49***	**Very High**
Establishing mathematics goals		*.43*	*3.52*	Very High
Performing Tasks		*.47*	*3.50*	Very High
Mathematical Representations		*.45*	*3.47*	Very High
Facilitating mathematical dialogue		*.46*	*3.49*	Very High
Posing meaningful questions		*.47*	*3.51*	Very High
Procedural Fluency		*.45*	*3.44*	Very High
Productive Struggle in Learning Math		*.45*	*3.49*	Very High
Deriving and Using Clues		*.43*	*3.48*	**Very High**

Based on the results, content knowledge variable obtained a mean of 3.27, which is described as very high. This indicates that teachers have very good Math content knowledge. All indicators are described as very high level except measurement. The standard deviation of 0.36, described as very low, reflects highly consistent responses among the respondents.

Moreover, the results reveal that pedagogical knowledge variable obtained a mean of 3.52, described as very high, indicating that teachers have very good Math pedagogical knowledge. All indicators are described at a very high level. The standard deviation of 0.41, described as very low, shows highly consistent responses.

Furthermore, the technological knowledge variable obtained a mean of 3.40, described as very high, indicating that teachers have very good technological knowledge. All indicators are described at a very high level. The standard deviation of 0.41, described as very low, shows consistent responses. Finally, teaching effectiveness obtained a mean of 3.49, described as very high, indicating that teachers have very good teaching effectiveness. All indicators are described at a very high level. The standard deviation of 0.36, described as very low, reflects highly consistent responses.

All variables, content knowledge, pedagogical knowledge, technological knowledge, and teaching effectiveness, are interpreted as very high, indicating that teachers consistently demonstrate very good competencies across these areas. Among them, pedagogical knowledge and teaching effectiveness are perceived slightly stronger in interpretation compared to content knowledge and technological knowledge, but all still reflect uniformly high and consistent performance.

3.2 Correlation Analysis

Table 2 is correlation table. It contains the predictors and criterion variable. Likewise, the r-value, p-value, decision on the hypothesis, and interpretation were included in the table.

Table 2: Correlation Table (n=129)

	Teaching Effectiveness			
Variables	**r-value**	**p-value**	**Decision on *Ho***	**Interpretation**
Content Knowledge	.693	.000	Reject *Ho*	Moderately high positive significant correlation
Pedagogical Knowledge	.759	.000	Reject *Ho*	High positive significant correlation
Technological Knowledge	.786	.000	Reject *Ho*	High positive significant correlation

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

The table specifically shows that the correlation between content knowledge and teaching effectiveness variables had a p-value of 0.000, which is less than the 0.05 level of significance. Hence, the null hypothesis was rejected, indicating that correlation is significant. The corresponding r-value of 0.693 shows a moderately high correlation. This implies that as teacher content knowledge increases, their teaching effectiveness practices also improve.

Meanwhile, the correlation between pedagogical knowledge and teaching effectiveness variables had a p-value of 0.000, also less than the 0.05 level of significance. Thus, the null hypothesis was rejected, indicating that correlation is significant. The corresponding r-value of 0.759 suggests a high correlation. This implies that as teacher pedagogical knowledge increases, their teaching effectiveness practices also increase.

Furthermore, the correlation between technological knowledge and teaching effectiveness variables had a p-value of 0.000, which is less than the 0.05 level of significance. Therefore, the null hypothesis was rejected, showing a significant correlation. The corresponding r-value of 0.786 indicates a high correlation. This implies that as teacher technological knowledge increases, their teaching effectiveness practices also improve.

All three variables were significantly correlated to teaching effectiveness, with technological knowledge showing the strongest relationship, followed by pedagogical knowledge, while content knowledge showed the weakest correlation.

3.3 Regression Analysis

Table 3 presents the results of the multiple linear regression analysis. The table includes the predictors and the criterion variable. The standardized and unstandardized beta coefficients, standard errors (SE), t-values, p-values, decision on null hypothesis, and interpretations are also shown. Moreover, it presented the regression summary, including the R, R^2, F-value, p-value, and the regression model equation.

Table 3: Regression Table (n = 129)

Variables	Teaching Effectiveness						
	Unstandardized Coefficient		Standardized Coefficient				
	β	Std. Error	β	T	Sig.	Decision on *H*0	Interpretation
Constant	0.53	0.17		3.06	0.003		
Content Knowledge	0.22	0.07	0.21	3.28	0.001	Reject H_0	Significant
Pedagogical Knowledge	0.28	0.06	0.32	4.36	0.000	Reject H_0	Significant
Technological Knowledge	0.37	0.07	0.41	5.65	0.000	Reject H_0	Significant

Model Summary:
$R = 0.85|R^2 = 0.72|F(3,125) = 106|p = 0.000$
Level of Significance:0.05
Decision Rule: Reject H_0 if $p < 0.05$
TE =0.53 + 0.22(CK) + 0.28(PK) + 0.37(TK)

It specifically shows that the predictive model for teaching effectiveness, using content knowledge, pedagogical knowledge, and technological knowledge as predictors, is TE =0.53 + 0.22(CK) + 0.28(PK) + 0.37(TK). The corresponding p-value obtained is 0.000. Such values are less than the 0.05 level of significance. Thus, the null hypothesis was rejected. It indicates that the said model to predict teaching effectiveness is significant. This finding implies that for every unit increase in content knowledge as a predictor in the model, there is a corresponding 0.22 unit increase in teaching effectiveness, holding other variables constant. Likewise, for every unit increase in pedagogical knowledge as a predictor in the model, there is a corresponding 0.28 unit increase in teaching effectiveness, holding other variables constant. Similarly, for every unit increase in technological knowledge as a predictor in the model, there is a corresponding 0.37 unit increase in teaching effectiveness, holding other variables constant. The constant value of 0.53 represents the baseline level of teaching effectiveness when all predictor variables are zero.

Furthermore, the result shows an R^2 value of 0.72, it is indicated that the model predicts effective teaching. The results indicate that content knowledge, pedagogical knowledge, and technological knowledge collectively contribute 72% of the variance. The F-value of 106 further confirms that the regression model is statistically significant, indicating that the predictors collectively have a meaningful influence on effective teaching.

3.4 Correlation between Content Knowledge and Teaching Effectiveness

The finding shows that content knowledge has a moderately high, significantly positive correlation with teaching effectiveness. This current finding supports the idea of Wang and Shapii (2025), indicating that teachers with strong content knowledge are better able to organize subject matter and anticipate student misconceptions, thereby improving instructional quality and student learning outcomes. Similarly, the current finding also supports the study of Bueno (2023), emphasizing that mastery of subject matter enhances a teacher's ability to clarify concepts and strengthen student understanding. However, this current finding contradicts the claim of Mafa-Theledi (2024), suggesting that content knowledge alone may not always lead to teaching effectiveness, indicating that other factors beyond content knowledge can influence instructional effectiveness.

3.5 Correlation between Pedagogical Knowledge and Teaching Effectiveness

The finding shows that pedagogical knowledge has a high, significantly positive correlation with teaching effectiveness. This current finding supports the study of Zhang and Li (2025), emphasizing that well-developed pedagogical knowledge enhances teaching quality and facilitates effective technology integration in education. The current finding also supports Abdullahi et al. (2025), who demonstrated that strong pedagogical knowledge correlates with teaching practices across different educational contexts. However, this current finding contradicts Dur et al. (2023), who reported that although pedagogical knowledge has a significant relationship with teaching effectiveness, the correlation was weak, suggesting that other factors may also play a substantial role in influencing instructional outcomes.

3.6 Correlation between Technological Knowledge and Teaching Effectiveness

The finding shows that technological knowledge has a high, significantly positive correlation with teaching effectiveness. This current finding supports the study of Piro et al. (2025), emphasizing that technology enhances teacher knowledge, skills, attitudes, and motivation, contributing to more effective teaching practices. The current finding also supports the study of Alison and Dioso (2025), demonstrating that integrating technology through innovative models like SAMR significantly improves instructional effectiveness and student learning outcomes. However, this current finding contradicts the idea of Tondeur et al. (2023), suggesting that technological knowledge alone may not always lead to teaching effectiveness practices unless supported by pedagogical beliefs and contextual conditions.

3.7 Content, Pedagogical, and Technological Knowledge Predict Teaching Effectiveness

The current study claims that content knowledge, pedagogical knowledge, and technological knowledge have a significant combined effect on teaching effectiveness, which was found to be significant, indicating that the integration of these domains enhances instructional effectiveness. This current finding supports the idea of Bueno et al. (2023), emphasizing that the interaction of content, pedagogy, and technology forms a comprehensive knowledge base that strengthens teaching practices. This current finding also supports Kholid et al. (2023), who highlighted that the integration of technological, pedagogical, and content knowledge is essential in improving teaching effectiveness and facilitating meaningful learning experiences. However, this current finding contradicts Tondeur et al. (2023), who stated that technological knowledge does not always significantly predict teaching effectiveness unless supported by other contextual and pedagogical conditions, suggesting that the combined influence of TPACK components may vary depending on teacher beliefs, professional development, and school environment.

4. Conclusion

Based on the findings, the teaching effectiveness was significantly forecasted by content knowledge, pedagogical knowledge, and technological knowledge as predictors. The model strongly (72%) predicts the criterion. This result supports the TPACK framework, which emphasizes that the integration of content, pedagogy, and technology is essential in enhancing teaching effectiveness and improving student learning outcomes.

5. Recommendation

Based on the conclusion, it is recommended that educational leaders may adopt a holistic approach in professional development programs by continuously strengthening teachers' content knowledge, pedagogical knowledge, and technological knowledge. Future researchers may also investigate other factors contributing to the remaining variance in teaching effectiveness and conduct qualitative studies to gain deeper insights into effective teaching practices.

Acknowledgements

I want to express my sincere gratitude to all those who contributed to the success of this research. I am especially thankful to Dr. Carlito P. Yurango, my research adviser, for his invaluable guidance and support, and for granting me the opportunity to conduct this research within his company. I am deeply appreciative of the knowledge and encouragement he provided throughout this journey. Above all, I thank God Almighty, the author of knowledge and wisdom, for His unconditional love and mercy.

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