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The Influence of Artificial Intelligence Competence and Digital Literacy on Science Teaching Efficacy: A Diagnostic Research Design

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Abstract — Poor science teaching efficacy is problem in education. The significance of Artificial Intelligence Competence and Digital Literacy as factors of Science Teaching Efficacy was determined. Using diagnostic research design, analyzing the 225 stratified random selected samples using multiple linear regression data analysis technique, the finding partially affirms Social Cognitive Theory, highlighting the significant strong influence (65%) of AI competence and digital literacy. Future studies may explore additional variables to trace the 35% variance in the criterion; and promote AI competence and digital literacy programs to strengthen science teaching efficacy.

Keywords: Influence of artificial intelligence competence, digital literacy, science teaching efficacy, diagnostic research design

I. INTRODUCTION

The Problem and Its Scope

Poor science teaching efficacy remains a serious global concern, as the quality of science instruction closely shapes students' learning experiences. According to Hidayah et al. (2023), research consistently shows that teacher efficacy is a strong determinant of educational quality, and low efficacy continues to pose a significant challenge in schools worldwide. Toma et al. (2025) emphasise that this problem is particularly evident in science education, where inadequate teaching efficacy persists. Poor science teaching efficacy is also evident across various countries. Mohammed and Luguterah (2024) found that science teachers in Ghana had low self-efficacy for

inquiry-based science teaching outside professional development contexts, highlighting the persistence of this issue in science classrooms.

Similarly, Toma et al. (2025) identified low efficacy in inquiry-based science teaching as an ongoing concern in Spain, with many teachers reporting a lack of confidence in delivering science through inquiry. In Türkiye, Sari and Balkas-Yasar (2024) found that a considerable proportion of science teachers reported insufficient self-efficacy in teaching competencies related to 21st-century skills.

Padohinog et al. (2024) highlighted that poor science teaching efficacy also remains a relevant concern in the Philippine context. Similarly, Antonio (2023) treated teacher self-efficacy as a significant educational concern amid changing instructional conditions, underscoring that efficacy remains a critical issue warranting attention in the local context.

Poor science teaching efficacy has serious consequences for both teachers and learners. Ma et al. (2025) found that teacher self-efficacy is significantly associated with student academic performance, suggesting that low teacher self-efficacy can place student learning at risk. Beyond student outcomes, Li (2023) found that low teacher self-efficacy is also positively associated with burnout, suggesting that poor efficacy can significantly undermine teachers' professional well-being and overall job satisfaction. In science education, Toma et al. (2025) further argued that low efficacy may limit the effective use of inquiry-based instruction, reducing opportunities for learners to develop scientific understanding and scientific literacy. These effects prompted this study.

Significance of the Study

This study is significant because improving science teaching efficacy supports Sustainable Development Goal 4, which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, since confident and effective science teachers are essential to meaningful learning and better learner outcomes. It is also important to the Department of Education’s national mission of protecting and promoting every Filipino’s right to quality, equitable, culture-based, and complete basic education, because stronger science teaching efficacy can help teachers deliver better instruction and create more effective learning environments.

Moreover, the study supports the vision and mission of Holy Cross of Davao College by contributing knowledge that can help form competent, values-oriented, and Christ-centred educators through quality education. In this way, the study may guide the teacher.

Statement of the Problem

This study examined the extent to which artificial intelligence competence and digital literacy contribute to science teaching efficacy. Specifically, it sought:

To determine the levels of artificial intelligence competence of science teachers in terms of AI knowledge, AI pedagogy, AI assessment, AI ethics, human centered education and professional engagement; digital literacy of science teachers in terms of communication, copyright, critical thinking, character, citizenship, curation, connectedness, creativity, and collaboration; and science teaching efficacy in terms of student engagement, instructional strategies, and classroom management.

1. To determine the significance of the relationship between artificial intelligence competence, digital literacy, and the science teaching efficacy

2. To determine the significance of the distinct and combined influence of artificial intelligence competence and digital literacy on science teaching efficacy

Hypothesis

Null Hypotheses (H_0):

H_{01}: Artificial Intelligence Competence and Digital Literacy do not significantly correlate with science teaching efficacy

H_{02}: Artificial Intelligence Competence and Digital Literacy have no significant distinct and combined influence on science teaching efficacy

Theoretical Framework:

This study applies Bandura's Social Cognitive Theory (1977, 1986), which posits that human behaviour emerges from the dynamic, reciprocal interaction among personal factors, behavioural patterns, and environmental influences. The theory further holds that individuals act as active agents who learn through direct experience, observation, modelling, and cognitive processing. Central to the framework is the concept of self-efficacy — defined as one's belief in one's own capabilities to execute specific tasks — which critically shapes behaviour and performance (Bandura, 1977, 1989, 2001).

In this study, Chiu et al. (2025) conceptualised Artificial Intelligence Competence — encompassing AI knowledge, AI pedagogy, AI assessment, AI ethics, human-centred education, and professional engagement — as a set of personal factors within Social Cognitive Theory. Similarly, Amin et al. (2022) identified Digital Literacy — comprising communication, copyright, critical thinking, character, citizenship, curation, connectedness, creativity, and collaboration — as corresponding to the same personal factors. Within this framework, Gálvez-Nieto et al. (2023) positioned science teaching efficacy as the behavioural dimension, capturing student engagement, instructional strategies, and classroom management.

Conceptual Framework:

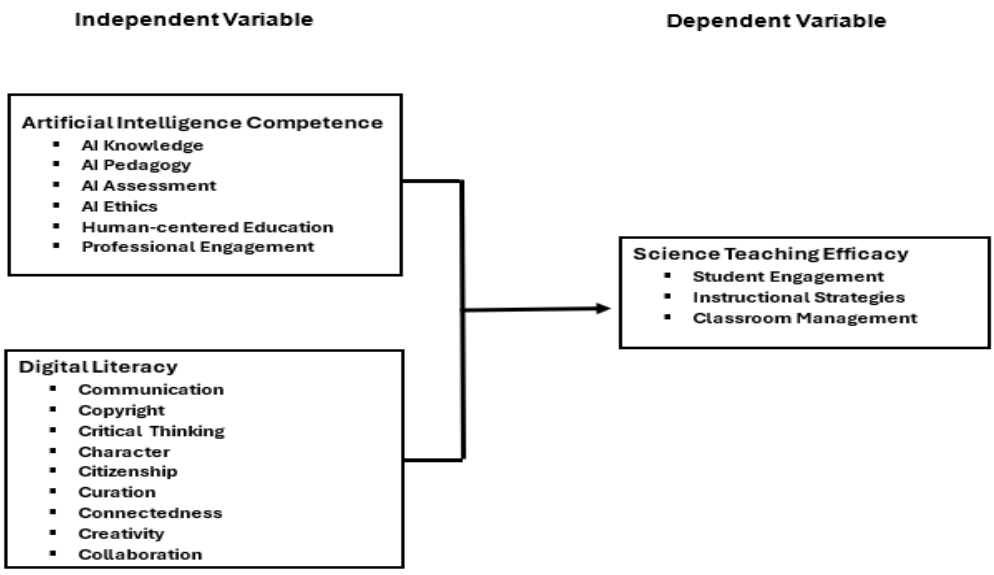

FIGURE 1
CONCEPTUAL FRAMEWORK OF THE STUDY.

II. METHODOLOGY

Research Design

This study employed a diagnostic research design, which Best and Kahn (2016) describe as appropriate for assessing current levels of variables and examining their relationships without manipulating respondents' natural settings. A diagnostic research design is also structured and problem-oriented, enabling researchers to examine present conditions, identify relevant patterns or relationships, and determine the strength of predictor variables in influencing a given outcome, as established by Wisenthige (2023) and Samanth (2024).

Locale of the Study

The researcher conducted this study in Digos City, Davao del Sur, Philippines, under the jurisdiction of the Schools Division Office of Digos City, which is part of the Department of Education (DepEd) Region XI. The Schools Division of Digos City oversees a public basic education system with a substantial elementary school population, making it an educationally appropriate locale for a study on Science Teaching Efficacy among elementary science teachers.

Sample and Sampling Technique

The study involved 225 elementary science teachers from 36 selected public elementary schools. The researcher did not consider sex and years of teaching experience as selection criteria, ensuring that all qualified science teachers had an equal opportunity to participate in the study.

The researcher employed stratified random sampling to ensure proportionate representation of teachers across schools and districts. The researcher obtained the official list of qualified science teachers from the Division Office and school heads, then randomly selected respondents who actively integrate artificial intelligence and digital tools in science instruction. Applying Slovin's formula with a 5% margin of error, the researcher computed the sample size to ensure the data were statistically representative and reliable.

Data Gathering Technique

The researcher used a survey questionnaire as the primary data-gathering instrument. A survey employs a standardised set of questions to collect self-reported information from respondents regarding their knowledge, opinions, attitudes, behaviours, or experiences. Goodfellow (2023) and Ranganathan and Caduff (2023) note that researchers commonly use surveys to gather systematic, comparable data from large groups of respondents in a practical, economical, and efficient manner.

This study used three sets of questionnaires to measure artificial intelligence competence, digital literacy, and science teaching efficacy. The first instrument was an adapted version of the Teacher AI Competence Self-Efficacy Scale (TAICS), developed by Chiu et al. (2024) in their study "Development and Validation of Teacher Artificial Intelligence (AI) Competence Self-Efficacy Scale," published in Education and Information Technologies. The TAICS consists of 28 items designed to assess the level of artificial intelligence competence among elementary science teachers.

The second instrument was an adapted version of the Digital Literacy Scale (DLS), developed by Amin et al. (2021) in their study "Development and Validation of Digital Literacy Scale (DLS) and its Implication for Higher Education." The DLS consists of 36 items that measure respondents' perceived digital literacy skills. The third instrument was an adapted version of the Teachers' Sense of Efficacy Scale (TSES), originally developed by Tschannen-Moran and Hoy (2001). The TSES consists of 24 items that measure science-teaching efficacy across three dimensions: student engagement, instructional strategies, and classroom management.

The researcher subjected the survey questionnaire to expert validation and pilot testing to ensure its accuracy and effectiveness. Validity refers to the extent to which an instrument measures what it intends to measure (Creswell & Creswell, 2018). Gliem and Gliem (2003) established that Cronbach's alpha is an appropriate measure of internal consistency; thus, the researcher subjected the pilot test data to reliability analysis using this coefficient to evaluate the internal consistency of each instrument's items. The results revealed high internal consistency, with Cronbach's alpha values of 0.954 for Artificial Intelligence Competence, 0.977 for Digital Literacy, and 0.982 for

Science Teaching Efficacy — indicating that all three instruments were highly reliable for data collection. The researcher retained all items, as each met acceptable reliability standards.

Data Analysis Technique

This study employed three data analysis techniques: descriptive analysis, correlation analysis, and multiple linear regression analysis.

Descriptive analysis provides a clear summary of the characteristics and distribution of a dataset without establishing causal relationships among variables. Chartexpo (2024), SurveyPoint (2022), and ATLAS.ti (2024) note that researchers in educational research commonly use descriptive analysis to describe the level and distribution of variables and to provide baseline information about respondents and the phenomena under study. The researcher employed descriptive analysis to summarise, organise, and present the data in a meaningful and interpretable manner, specifically using the mean and standard deviation to determine the levels of the three key variables: Artificial Intelligence Competence, Digital Literacy, and Science Teaching Efficacy.

The researcher employed correlation analysis to examine the relationships among the selected variables. Specifically, the researcher used the Pearson product–moment correlation coefficient (r) to measure the strength and direction of the association between variables. Correlation analysis helps determine whether changes in one variable are related to changes in another, without implying a cause-and-effect relationship. Akoglu (2022) and Schober et al. (2022) established that researchers commonly use correlation analysis in quantitative research to examine associations among variables and to determine whether they are suitable for further analysis, such as regression.

Computed *r*	**Descriptive 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

The researcher employed multiple linear regression analysis to determine the influence of multiple independent variables on the dependent variable. Multiple linear regression allows the researcher to examine the combined and individual effects of the predictor variables while controlling for the influence of other variables in the model. The technique also helps identify which independent variables significantly contribute to variations in the dependent variable. Ju et al. (2023) and Xu et al. (2023) established that researchers commonly use multiple linear regression in quantitative research to analyse complex relationships among variables and develop predictive models.

The matrix below presents the descriptive levels and corresponding interpretations assigned to each of the three variables — AI Competence, Digital Literacy, and Science Teaching Efficacy — examined in the study.

Range of Mean	Descriptive Level	AI Competence	Digital Literacy	Science Teaching Efficacy
3.26 - 4.00	Very High	Very Good	Very Good	Very Strong
2.50 – 3.25	High	Good	Good	Strong
1.75 - 2.49	Low	Poor	Poor	Weak
1.00 – 1.74	Very Low	Very Poor	Very Poor	Very Weak

In this study, the researcher tested the significance of the correlation at a 0.05 confidence level and interpreted the r-values following the standard scale proposed by Guilford (1956), as outlined below:

The following is the Standard Deviation Value Interpretation:

Range	Description	Interpretation
SD $\leq$ 0.50	Highly Consistent Responses	Strong and uniform perception
SD = 0.51 – 1.00	Moderately Consistent Responses	Acceptable consistency
SD = 1.01 – 1.50	Low Consistency Responses	Differing views or experiences
SD > 1.5	Very Low Consistency Responses	High variability and lack of consensus

The researcher employed multiple linear regression analysis to determine the predictive influence of Artificial Intelligence Competence and Digital Literacy on Science Teaching Efficacy. Following Hair et al. (2022), multiple linear regression uses both unstandardized and standardized beta coefficients to assess the relative contribution of each predictor to the outcome variable, assuming a linear relationship among the variables.

In terms of Scale of Beta (β) Coefficient Strength, the following scheme, as proposed by Cohen (1988) and Hair et al. (2019), was used:

β Value Range	**Strength of Influence**
± 0.00 - ± 0.09	Very Weak
± 0.10 - ± 0.29	Weak
± 0.30 - ± 0.49	Moderate
± 0.50 - ± 0.69	Strong
± 0.70 and above	Very Strong

Ethical Consideration

The researcher observed the ethical principles of institutional approval, informed consent, voluntary participation, confidentiality, anonymity, and data protection throughout the study. Before data collection, the researcher secured approval from the Holy Cross of Davao College – Society for Moral Integrity and Legal Ethics (HCDC-SMILE), the Department of Education Division Research Committee, and the school heads of the participating schools. The researcher informed all respondents of the study's purpose and procedures and assured them that participation was entirely voluntary and that they could withdraw at any time without consequence. The researcher strictly maintained confidentiality, anonymity, and privacy by excluding identifying information from the report and using the data solely for academic purposes. The American Educational Research Association (AERA, 2011) Code of Ethics guided all research procedures to ensure the protection of participants' rights, dignity, and welfare.

III. RESULTS

This chapter presents the results of the descriptive, correlation, and regression analyses, along with a summary of the findings.

Descriptive Results

Table 1 presents the descriptive statistics for the three study variables — Artificial Intelligence Competence, Digital Literacy, and Science Teaching Efficacy — along with their respective indicators, including the sample size, computed means, standard deviations, and corresponding descriptive interpretations for each variable.

TABLE 1
DESCRIPTIVE STATISTICS (N = 225)

Variables	Standard Deviation	Mean	escriptive Level
Artificial Intelligence Competence	**0.41**	**3.52**	**Very High**
AI Knowledge	*0.46*	*3.53*	*Very High*
AI Pedagogy	*0.45*	*3.53*	*Very High*
AI Assessment	*0.48*	*3.47*	*Very High*
AI Ethics	*0.50*	*3.50*	*Very High*
Human Centered Education	*0.46*	*3.52*	*Very High*
Professional Engagement	*0.47*	*3.53*	*Very High*
Digital Literacy	**0.42**	**3.52**	**Very High**
Communication	*0.50*	*3.48*	*Very High*
Copyright	*0.48*	*3.52*	*Very High*
Critical Thinking	*0.55*	*3.46*	*Very High*
Character	*0.45*	*3.67*	*Very High*
Citizenship	*0.43*	*3.66*	*Very High*
Curation	*0.47*	*3.59*	*Very High*
Connectedness	*0.51*	*3.49*	*Very High*
Creativity	*0.57*	*3.36*	*Very High*
Collaboration	*0.55*	*3.46*	*Very High*
Science Teaching Efficacy	**0.48**	**3.55**	**Very High**
Student Engagement	*0.49*	*3.54*	*Very High*
Instructional Strategies	*0.51*	*3.57*	*Very High*
Classroom Management	*0.50*	*3.55*	*Very High*

3.26-4.00=Very High; 2.5-3.25=High; 1.75-2.49=Low, 1.00-1.74=Very Low;

Specifically, Table 1 reveals that Artificial Intelligence Competence attained a very high level (M = 3.52, SD = 0.41), indicating that teachers are highly proficient in utilising artificial intelligence tools and concepts in their instructional practices. An SD ≤ 0.50 reflects highly consistent and uniform perceptions among respondents, and all indicators under this variable likewise attained a very high level. Similarly, Digital Literacy attained a very high level (M = 3.52, SD = 0.42), indicating that teachers are highly proficient in using digital technologies for teaching and professional tasks. An SD ≤ 0.50 reflects highly consistent and uniform perceptions among respondents, and all indicators under this variable equally attained a very high level. Lastly, Science Teaching Efficacy attained a very high level (M = 3.55, SD = 0.48), indicating that teachers demonstrate very strong confidence in their teaching abilities. An SD ≤ 0.50 reflects highly consistent and uniform perceptions among respondents, and all indicators under this variable likewise attained a very high level.

Table 1 reveals that Artificial Intelligence Competence, Digital Literacy, and Science Teaching Efficacy among science teachers all attained a very high level, indicating strong technological competence and instructional confidence. The results also indicate that the majority of teachers (n = 225) demonstrate high proficiency in integrating AI and digital tools into instruction. In particular, the very high level of Science Teaching Efficacy (M = 3.55, SD = 0.48) indicates that teachers demonstrate strong confidence in implementing instructional strategies, managing classrooms, and engaging students effectively. Lastly, an SD ≤ 0.50 across all three variables reflects highly consistent and uniform perceptions among respondents (n = 225), with all indicators under each variable likewise attaining a very high level.

Correlation Results

Table 2 presents the correlation analysis results for Artificial Intelligence Competence, Digital Literacy, and Science Teaching Efficacy, including the corresponding r-values, p-values, decisions on Ho, and their interpretations.

TABLE 2
CORRELATION TABLE (N=225)

Variables	Science Teaching Efficacy			
	r-value	p-value	Decision on H_0	Interpretation
Artificial Intelligence Competence	0.73	0.001	Reject H_0	Moderately High Positive, Significant
Digital Literacy	0.79	0.001	Reject H_0	High Positive, Significant

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

Specifically, Table 2 reveals that the correlation between Artificial Intelligence Competence and Science Teaching Efficacy yielded a p-value of 0.001, which is less than the 0.05 significance level, leading to the rejection of the null hypothesis. The result indicates a significant, moderately high correlation between the two variables, with an r-value of 0.73, which falls within the range of ±0.51 to ±0.74. Similarly, the correlation between Digital Literacy and Science Teaching Efficacy (n = 225) yielded a p-value of 0.001, which is less than the 0.05 significance level, leading to the rejection of the null hypothesis. Lastly, the result indicates a significant, high correlation between the two variables, with an r-value of 0.79, which falls within the range of ±0.75 to ±0.99.

Table 2 further reveals that both Artificial Intelligence Competence and Digital Literacy share a significant positive correlation with Science Teaching Efficacy. Of the two predictor variables, Digital Literacy demonstrates a stronger correlation with Science Teaching Efficacy (r = 0.79) than Artificial Intelligence Competence (r = 0.73), suggesting that teachers' digital proficiency more closely aligns with their science teaching efficacy.

Regression Results

Table 3 presents the regression table, showing the predictor variables and the criterion variable, along with their unstandardised and standardised beta coefficients, standard errors, t-values, significance values, null-hypothesis decisions, and interpretations.

TABLE 3
REGRESSION TABLE (N=225)

	Science Teaching Efficacy						
	Unstandardized Coefficients		**Standardized Coefficients**				
Factors	**B**	**Std. Error**	**Beta**	**t**	**Sig.**	**Decision on H_0**	**Interpretation**
(Constant)	0.18	0.17	–	1.03	0.305	–	–
Artificial Intelligence Competence	0.24	0.08	0.20	2.84	0.005	Reject	Positive Significant Influence
Digital Literacy	0.71	0.08	0.62	8.50	0.001	Reject	Positive Significant Influence

$R = 0.80$ | $R^2 = 0.65$ | $F = 203$ | $p = <.001$
Level of Significance: 0.05
Decision Rule: Reject H_0 if $p < 0.05$
Predictive Model: STE=0.24AIC+0.71DL+0.18

Specifically, Table 3 reveals that Artificial Intelligence Competence yielded a standardised beta coefficient of 0.20 with a corresponding p-value of 0.005, which is less than the 0.05 significance level, leading to the rejection of the null hypothesis. The results indicate that Artificial Intelligence Competence exerts a positive but weak influence on Science Teaching Efficacy, implying that for every one-unit increase in Artificial Intelligence Competence, Science Teaching Efficacy increases by 0.20 units.

Similarly, Table 3 reveals that Digital Literacy yielded a standardised beta coefficient (β = 0.62, p = 0.001), which falls short of the 0.05 significance level, indicating a significant positive predictor of Science Teaching Efficacy. This result leads to the rejection of the null hypothesis. The results indicate that Digital Literacy exerts a strong and significant positive influence on Science Teaching Efficacy, implying that for every one-unit increase in Digital Literacy, Science Teaching Efficacy increases by 0.62 units.

Summary of Findings

Based on the statistical analysis, the study found that:

Artificial Intelligence Competence and Digital Literacy share a significant positive correlation with science teaching efficacy.

Artificial Intelligence Competence and Digital Literacy have significant, distinct, and combined influences on science teaching efficacy.

IV. DISCUSSIONS

Discussed in this chapter are the findings of the study. This section also presents the conclusion and recommendations.

Artificial Intelligence Competence, Digital Literacy, and Science Teaching Efficacy

The present study found that Artificial Intelligence Competence and Digital Literacy are significantly correlated with Science Teaching Efficacy, suggesting that science teachers who are more skilled in Artificial Intelligence and Digital tools tend to be more confident in teaching. This finding supports Garzon and Garzon (2023), stating that teachers' digital literacy was positively associated with self-efficacy in blended learning. This finding also reinforces Widiyanti et al. (2025), who found that AI technology literacy positively influences teachers' self-efficacy in performing instructional tasks. Together, these studies support the idea that proficiency with

technology and digital tools enhances teachers' confidence and instructional effectiveness. However, this finding contradicts Kashihara et al. (2024), who reported a weak and non-significant relationship between AI literacy and teacher efficacy, suggesting that possessing AI knowledge alone does not necessarily enhance teaching confidence. This discrepancy may be attributable to differences in sample size: Kashihara et al. (2024) included only 25 participants, whereas the current study included 225.

Science Teaching Efficacy as Influenced by Artificial Intelligence Competence and Digital Literacy

The findings of this study indicate that both Artificial Intelligence Competence and Digital Literacy exert significant, distinct, and combined influences on Science Teaching Efficacy, suggesting that teachers who are more proficient in AI and digital tools tend to exhibit higher confidence and effectiveness in teaching science. This result supports Widiyanti et al. (2025), who found that AI technology literacy positively and significantly influences teachers' self-efficacy in performing instructional and leadership tasks. Furthermore, this finding aligns with Lim (2023) and Yao and Wang (2024), who found that higher digital competencies among prospective teachers are associated with stronger self-efficacy and greater readiness to integrate AI into instruction.

However, this finding contradicts Kumar (2025), who reported that the correlation between digital competence and teaching competence was not statistically significant. This discrepancy may be attributable to differences in sample size: Kumar's (2025) study included only 112 participants, whereas the current study included 225.

V. CONCLUSION

Based on the findings, the researcher concludes that Artificial Intelligence Competence and Digital Literacy are significant predictors of Science Teaching Efficacy, jointly accounting for 65% of its variance ($R^2 = 0.65$). Consequently, the findings provide partial support for Albert Bandura's Social Cognitive Theory (1977, 1986), which explains that the continuous interaction

among personal factors, behavioural actions, and environmental influences shapes human behaviour. In the context of the study, the participants' experiences show that their thoughts, decisions, coping actions, and surrounding conditions influenced one another as they responded to the challenges they encountered. The results suggest that a single factor did not shape their behaviour, but rather the dynamic relationship among what they believed, how they acted, and the environment in which they lived and learned. This theory emphasises the importance of behavioural influences and shows how the dynamic interplay among these elements produces behaviour. However, the affirmation is partial, as this study did not examine the dimension of environmental influences, which remains a limitation of the present research.

VI. RECOMMENDATIONS

Based on the study's conclusion, the researcher recommends that future researchers explore additional variables not covered in the study to account for the remaining 35% of the variance in Science Teaching Efficacy. Future researchers may also pursue a qualitative study to generate emerging themes that could serve as potential predictor variables. Furthermore, the researcher recommends that school leaders initiate programs to enhance Artificial Intelligence Competence and Digital Literacy among science teachers, thereby fostering stronger Science Teaching Efficacy.

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