KARYA ILHAM PUBLISHING
CONNECTING MINDS, BRIDGING IDEAS, INSPIRING READERS

ASEAN Artificial Intelligence Journal

Journal homepage:
https://karyailham.com.my/index.php/aaij/index
ISSN: 3083-9971

Analysis of Programming and Artificial Intelligence Based on Gemini Canvas in Supporting Deep Learning: A Structural Equation Modelling (SEM) Approach

Vicky Ainul Hayya Maulana[1,*], Subiyanto[1], Imron[2], Achmad Samsudin[3], Kuntoro Adi Juwanda[4]

[1] Education in Information Technology and Computer Science Study Program, Universitas Negeri Semarang, Indonesia
[2] Physics of Teacher, Senior High School 1 Lasem, Rembang, Indonesia
[3] Physics Education Program, Universitas Pendidikan Indonesia, Bandung, Indonesia
[4] Teacher of Indonesian School in Kuala Lumpur, Malaysia

ARTICLE INFO

Article history:
Received 30 July 2025
Received in revised form 28 August 2025
Accepted 15 September 2025
Available online 1 October 2025

Keywords:
coding, artificial intelligence, Gemini Canvas, deep learning

ABSTRACT

Highly skilled, resilient, and intelligent human resources require 21st-century skills. Students need more than just academic knowledge. Students urgently require core 21st-century skills, including digital literacy skills such as information literacy, media literacy, and technological literacy. To achieve these skills, coding and artificial intelligence (CAI) or progamming and artificial intelligence (PAI)education is needed to support deep learning as part of the implementation of learning skills and innovation—other 21st-century skills—to prepare human resources for Indonesia's Golden Age in 2045.The method used is a mixed method with data collection techniques in the form of documentation, observation, and questionnaires, analyzed using regression with the Structural Equation Modelling (SEM) approach in the Lisrel application. The issues are (1) to what extent can CAI based on Gemini Canvas support deep learning and (2) to what extent do the impact of digital literacy, human resources in artificial intelligence (AI), and the integration of AI in education on the implementation of CAI learning support deep learning through teachers' skills in CAI based on Gemini Canvas, either directly or indirectly? This research aims to (1) analyze how CAI based on Gemini Canvas can support deep learning and (2) determine the impact of digital literacy, human resources in AI, and the integration of AI in education on the implementation of CAI learning in supporting deep learning through teacher skills in CAI based on Gemini Canvas, either directly or indirectly. The results indicate that Gemini Canvas-based CAI can support deep learning, and the direct influence of the Gemini Canvas-based CAI teacher skill variable on the implementation of CAI learning in supporting deep learning is 0.65. Teachers' skills in CAI based on Gemini Canvas are directly influenced by digital literacy (0.27), human resources in AI (0.17), and the integration of AI in education (0.50). The indirect influence of the implementation of CAI learning in supporting learning is from digital literacy (0.176), human resources in AI (0.111), and the integration of AI in education (0.325). The impact of this research is that the 21st-century skills applied in CAI can support the implementation of deep learning to the fullest extent.

[*] *Corresponding author.*
E-mail address: vickymaulana5205@students.unnes.ac.id.com

https://doi.org/10.37934/aaij.3.12848

1. Introduction

The results of the 2022 Programme for International Student Assessment (PISA) serve as a serious reminder of the importance of basic literacy and 21st-century skills [25]. Indonesia's declining rankings in reading literacy, mathematics, and science indicate fundamental challenges that directly impact digital literacy among the population, particularly the younger generation. Digital literacy [2] is not merely about using technology but about the ability to evaluate, create, and collaborate within the digital ecosystem in a wise and effective manner. PISA measures students' ability to apply knowledge in real-world contexts, which is closely linked to critical thinking and problem-solving skills. Indonesia's low scores, with an average of 359 for reading literacy, 366 for mathematics, and 383 for science, indicate that students still struggle to understand and analyze complex texts, data, and scientific concepts. These foundational skills are an absolute prerequisite for strong digital literacy [1]. Without a strong foundation in reading literacy [18], an individual will struggle to evaluate the validity of information on the internet, distinguish between facts, opinions, and misinformation, and understand instructions or technical guides independently. Therefore, these low PISA rankings indirectly indicate a significant gap in substantive digital literacy, not just a gap in technology access.

In the era of digital transformation, the role of teachers has evolved far beyond their traditional function as conveyors of information [6]. Teachers are now required to become facilitators and guides for students as they navigate a world increasingly driven by technology. The basic competencies of teachers as defined by the government must now be enriched with technological literacy and skills, particularly in the fields of coding and artificial intelligence (AI). The government, through the Ministry, is currently striving to provide training and certification for selected teachers to ensure they have the necessary qualifications to teach this material. This is an important investment in preparing Indonesia's youth to face global challenges in the future. Coding [26] is how we build tools, while AI is the result we create using those tools to enable machines to think and learn. AI is an evolution of coding, where the focus shifts from merely executing instructions to creating adaptive and intelligent entities.

A large number of studies have tested the effectiveness of AI in personalizing the learning experience [33]. Studies show that AI-powered intelligent tutoring systems are able to adjust the curriculum and level of difficulty in real time based on student performance, demonstrating that these systems can provide individualized guidance that is as effective as that provided by human tutors. Key findings from this area indicate that personalization can enhance learning outcomes, motivation, and retention of material. However, some studies also highlight the limitations of these systems, such as the lack of social and emotional interaction that human teachers can provide [4]. Studies show that AI algorithms can identify patterns in student behavior, such as signs of boredom, frustration, or risk of dropping out, long before teachers notice them by examining how AI can predict student performance and provide early warnings to teachers. The goal is to enable teachers to intervene in a timely and targeted manner. Research has shown that AI-based assessment tools can provide instant feedback on essays or structured assignments, freeing up teachers' time for deeper interaction with students. Additionally, there is research exploring AI as a virtual assistant that helps teachers create lesson plans, find resources, and manage classrooms.

Early research shows that using Gemini Canvas can enhance higher-order thinking processes in students. The platform allows students to interact with AI to organize ideas, create concepts, and compose content in visual or structured formats. For example, a student can ask AI to create an essay outline or generate an initial code draft for a project. This allows students to bypass initial barriers (writer's block or coder's block) and focus directly on deeper learning aspects, such as analyzing arguments or refining logic. Gemini Canvas, with its collaborative nature, has also been researched in the context of developing 21st-century skills. The platform uniquely combines AI capabilities with a shared workspace, enabling research to evaluate how students collaborate with AI and their peers.

The application of artificial intelligence (AI) in deep learning (referring to pedagogy, not technology) is a rapidly growing area of research. Historically, studies have focused on general AI tools such as intelligent tutoring systems and learning analytics. However, with the emergence of generative AI-powered collaborative platforms such as Gemini Canvas, the literature is beginning to shift toward exploring the specific potential of these tools. Gemini Canvas, with its collaborative nature, has also been studied in the context of developing 21st-century skills. This platform uniquely combines AI capabilities with a shared workspace, enabling research to evaluate how students collaborate with AI and fellow students.

Overall, previous studies provide compelling evidence that AI has great potential to transform classroom learning, particularly through personalization and efficiency. However, as a researcher, I see that successful implementation depends heavily on a deep understanding of ethical and practical challenges. Strategic steps are needed to address bias, ensure data privacy, and train teachers so they can use AI as a powerful tool, not a replacement. Previous studies on the use of Gemini Canvas and similar AI platforms in deep learning [27] demonstrate significant potential for enhancing problem-solving, creativity, and collaboration. These platforms not only serve as tools but also as environments where students can learn how to work with advanced technology [24]. This research also highlights the need for ethical and thoughtful approaches, with a focus on the role of teachers as facilitators who teach AI literacy and ensure that technology is used to empower students, not to replace their thinking processes [36]. Previous studies on the use of Gemini Canvas and similar AI platforms in deep learning [28] demonstrate significant potential for enhancing problem-solving, creativity, and collaboration. This platform serves not only as a tool but also as an environment where students can learn how to work with advanced technology. This research also highlights the need for an ethical and thoughtful approach, with a focus on the role of teachers as facilitators who teach AI literacy and ensure that technology is used to empower students, not to replace their thinking processes [23].

The issues are (1) to what extent can CAI based on Gemini Canvas support deep learning and (2) to what extent do the impact of digital literacy, human resources in artificial intelligence (AI), and the integration of AI in education on the implementation of CAI learning support deep learning through teachers' skills in CAI based on Gemini Canvas, either directly or indirectly? This research aims to (1) analyze how CAI based on Gemini Canvas can support deep learning and (2) determine the impact of digital literacy, human resources in AI, and the integration of AI in education on the implementation of CAI learning in supporting deep learning through teacher skills in CAI based on Gemini Canvas, either directly or indirectly.

2. Methodology

2.1 Participant and Data Collection

The sample in this study consisted of 613 respondents who were given a questionnaire after attending an online seminar, comprising 252 primary school teachers, 351 secondary school teachers, and 10 university lecturers and members of the general public. The respondent data obtained during the study are presented in Table 1.

Table 1
Respondent Profile of Participant

Description	Frequency	(%)
Kindergarten	7	1.14
Elementary School	104	16.97
Junior High School	141	23.00
Senior High School/Vocational School	351	57.26
College	4	0.65
General	6	0.98

2.2 Research Design and Instruments

This study used a quantitative method through an online questionnaire using Google Forms [16]. The effectiveness of using Gemini Canvas-based Artificial Intelligence in supporting the implementation of deep learning approaches was tested after an online seminar on artificial intelligence for teachers. Participants responded to the effectiveness of using Gemini Canvas-based programming and artificial intelligence in supporting the implementation of deep learning approaches through a questionnaire with a 1-5 Likert scale provided in the form of a Google Form [7].

The instruments used in this study analyzed the effectiveness of using Gemini Canvas-based artificial intelligence in supporting the implementation of deep learning, including digital literacy, human resource competencies in artificial intelligence, and the integration of Gemini Canvas-based artificial intelligence in learning. The distribution of instruments is shown in Table 2.

Table 2
Instruments used in research according to specified variables

Variable	Total
Digital Literacy	5
Human Resources in Artificial Intelligence	5
Integration of Artificial Intelligence in Education	5
The Application of Coding and Artificial Intelligence and Coding in Learning	9
Teachers' Skills in Artificial Intelligence Coding based on Gemini Canvas	7

2.3 Analysis Technique

The data were analyzed using an integrative approach by combining various data sources through observation or literature to find relationships and participate in related theories in a collaborative and reflective process. Path analysis was conducted using the Structural Equation Modelling (SEM) approach with SPSS version 25 and Lisrel version 8.8. SEM involves three simultaneous activities. This was done to enrich and clarify the results interpreted explicitly to approach the actual results [31].

Research data is analyzed using Structural Equation Modelling (SEM) with the Lisrel application [9]. SEM is used to combine confirmatory factor analysis (CFA) with regression analysis, between CFA and path analysis, as well as the combination of structural models and measurement models. SEM can analyze the patterns of relationships between latent variables and their indicators, latent variables with other latent variables, as well as measurement errors. SEM can provide an in-depth explanation of the relationships between variables in the research, provided that the hypothetical model is constructed as a diagram consisting of structural models and measurement models based on theoretical justification. The following are the stages of data analysis:

i. Validity and Reliability Test Analysis. The validity test of each indicator item in the questionnaire used was analysed using the Lisrel application version 8.8. An indicator is said to be valid if the standardization value between the indicator and the variable is above 0.50. Reliability tests were carried out on questionnaires that met the validity test using the results of the Lisrel application. It is said to be reliable if the Construct Reliability (CR) value is > 0.50 or Variance Extracted (VE) > 0.50, the following equation:

$$CR = \frac{(\sum Standardized\ Loading)^2}{(\sum Standardized\ Loading)^2 + (\sum Measurenment\ Error)} \text{And} VE = \frac{(\sum Std.Loading\ g)^2}{(\sum Std.Loading\ g)^2 + (\sum e)} \quad (1)$$

ii. Classical Assumption Test Analysis includes normality test, multicollinearity test, and heteroscedasticity test. In SEM, the model is said to be fit if the RMSEA value is <0.05.
iii. Direct and indirect impacts. Simultaneous and indirect influence tests were obtained from the confirmatory factor analysis (CFA) output of the Lisrel application. The regression equation must satisfy the following equation:

Structure 1:

$$Z = a\ X1 + b\ X2 + c\ X3 + \delta \quad (2)$$

Structure 2:

$$Y = a\ X1 + b\ X2 + c\ X3 + \delta \quad (3)$$

Structure 3:

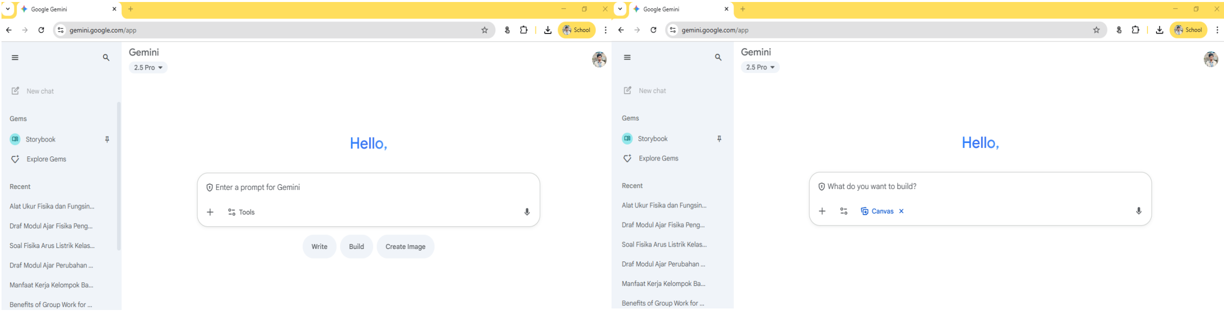
$$Y' = a'\ X1 + b'\ X2 + c'\ X3 + d\ Z + \delta \quad (4)$$

3. Results

3.1 Pressure Distribution

Programming Skills and Artificial Intelligence Based on Gemini Canvas for Teachers at the Following Stages:

i. Gemini Canvas Preparation: Teachers need to understand how Gemini and Gemini Canvas work and their main features. This can be achieved through tutorials or initial training that provide an in-depth understanding of how to use the platform. Once teachers have mastered Gemini Canvas, the next step is to prepare teaching modules or in-depth lesson plans. These materials should align with the curriculum and meet students' needs to ensure that the in-depth learning process is effective and efficient. By understanding Gemini Canvas and preparing relevant materials, teachers can maximize the benefits of artificial intelligence to support in-depth learning using Gemini Canvas. See Figure 1.

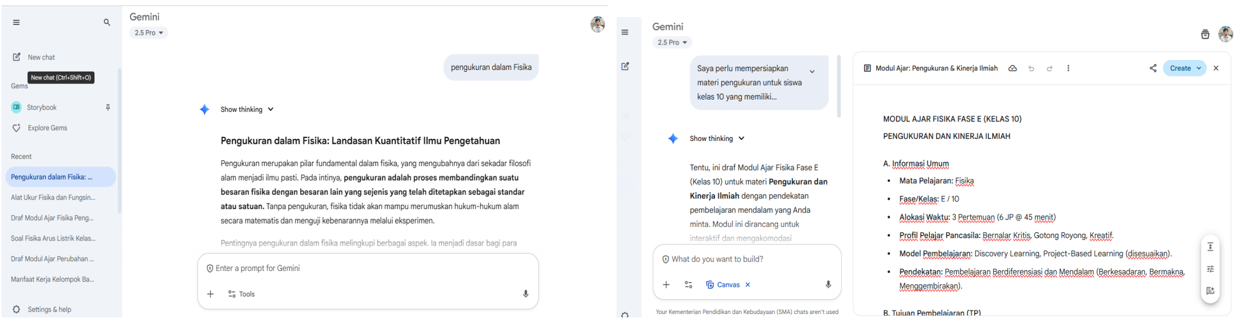


(a) Gemini (b) Gemini Canvas

Fig. 1. Preparing Gemini Canvas Artificial Intelligence

ii. Using Gemini Canvas Artificial Intelligence to support deep learning: Start by introducing Gemini Canvas to students, showing them how to use the basic tools and features. Continue with interactive activities, such as creating contextual learning experiences related to real-life situations that students can engage with while encouraging active participation. Finally, allow students to explore Gemini Canvas independently to complete tasks or projects, which will help them understand these concepts more deeply. See Figure 2.

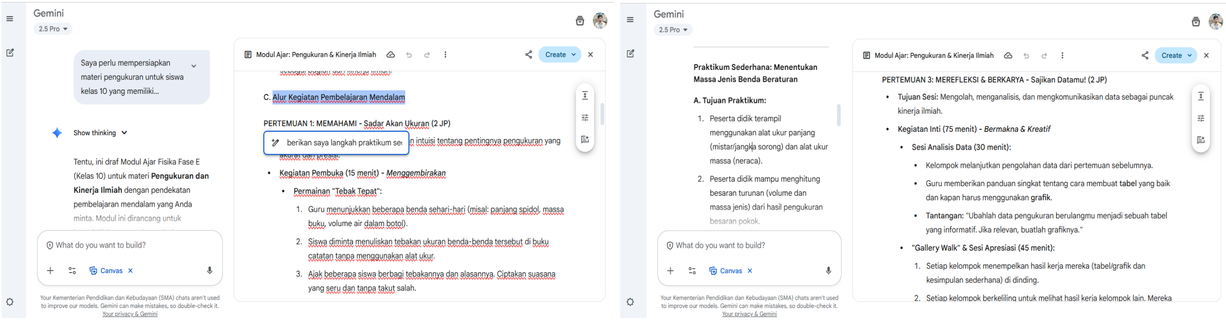
iii.



(a) Gemini canvas without prompts (b) Gemini canvas with prompts

Fig. 2. Use Gemini Canvas to Artificial Intelligence in the classroom

iv. Use for Evaluation: To effectively integrate Gemini artificial intelligence into the deep learning process, it is essential to create exercises and tests that students can complete using this platform. This allows teachers to evaluate students' understanding in real time, enabling them to identify areas where students may need additional support. These exercises and tests should be designed to cover a range of mathematical concepts, providing a comprehensive evaluation of students' abilities. In addition to real-time evaluation, providing immediate feedback on tasks completed with the help of Gemini Canvas artificial intelligence is essential. This immediate feedback allows students to quickly identify and correct their mistakes, reinforcing their understanding and aiding in concept retention. The interactive nature of Gemini Canvas artificial intelligence also makes it easier for teachers to highlight specific errors and explain the correct methods, creating a more effective learning environment. This approach not only increases student engagement but also ensures a deeper understanding of mathematical concepts, ultimately leading to improved academic performance. Canvas is a digital workspace for complex projects. Manual editing is the key to success. One project in Canvas can serve as a source for various derivative teaching materials. Teachers are the architects of learning, and Gemini is the design assistant that helps bring the teacher's vision to life. Figure 3.



(a) Gemini Canvas with automatic editing (b) Gemini Canvas with manual edit

Fig. 3. Use Gemini Canvas to evaluation and reflection in the classroom

v. Teacher Professional Development: Creating a discussion forum where teachers can share their experiences and best strategies for using Gemini Canvas artificial intelligence is an important step in professional development to support deep learning. This collaborative space enables educators to exchange insights, discuss challenges, and offer practical solutions. By better integrating Gemini Canvas artificial intelligence into learning, this ultimately enhances student engagement and understanding.

vi. Evaluation and Improvement: Regular evaluation of the effectiveness of using Gemini Canvas artificial intelligence in learning is essential to ensure its continued success and support deep learning. Collecting feedback from students and teachers provides valuable insights into what is working well and what needs to be adjusted. This feedback loop enables continuous improvement, as teachers can make informed adjustments in the use of Gemini Canvas AI based on these evaluations. By regularly refining and enhancing the implementation of Gemini Canvas AI, educators can ensure that Gemini Canvas AI remains a dynamic and effective tool for improving the quality of learning and meeting students' evolving needs to support deep learning.

The results of validity and reliability tests were obtained for each variable (CR = construct reliability and VE = variance extracted) using Lisrel 8.8 as part of SEM (Structural Equation Modelling) and are summarized in Table 3.

Table 3

Validity and reliability testing for 613 respondents using Lisrel 8.8

Variable	Total	Valid	CR	Result	VE	Result
Digital Literacy	5	5	0.9022	Reliable	0.6489	Reliable
Human Resources in Artificial Intelligence	5	5	0.9152	Reliable	0.6835	Reliable
Integration of Artificial Intelligence in Education	5	5	0.8884	Reliable	0.6156	Reliable
The Application of Coding and Artificial Intelligence and Coding in Learning	9	9	0.9489	Reliable	0.6740	Reliable
Teachers' Skills in Artificial Intelligence Coding based on Gemini Canvas	7	7	0.9406	Reliable	0.6939	Reliable

The results in Table 3 show that all indicators are >0.50, so all are valid. The results of CR>0.70 and VE>0.500 indicate that all variables are reliable. The results in able 1 correspond to the goodness of fit statistical output in the Lisrel 8.8 application as follows:

DATE: 8/13/2025
TIME: 02:05
L I S R E L 8.80
BY
Karl G. Jöreskog & Dag Sörbom

```
The following lines were read from file H:\dataKKA\KKAanalisis1.spj:
 Raw Data from file 'H:\dataKKA\KKAanalisis1.psf'
 Sample Size = 613
 Latent Variables  DL HRAI IAIE TSAI ACICL
 Relationships
 X1-X5=DL
 X6-X10=HRAI
 X11-X15=IAIE
 Z1-Z9=TSAI
 Y1-Y7=ACICL
 Path Diagram
 End of Problem
Sample Size =   613
Goodness of Fit Statistics
Degrees of Freedom = 424
Minimum Fit Function Chi-Square = 2667.81 (P = 0.0)
Normal Theory Weighted Least Squares Chi-Square = 2858.42 (P = 0.0)
Estimated Non-centrality Parameter (NCP) = 2434.42
90 Percent Confidence Interval for NCP = (2268.84 ; 2607.41)
Minimum Fit Function Value = 4.36
Population Discrepancy Function Value (F0) = 3.98
90 Percent Confidence Interval for F0 = (3.71 ; 4.26)
Root Mean Square Error of Approximation (RMSEA) = 0.097
90 Percent Confidence Interval for RMSEA = (0.094 ; 0.10)
P-Value for Test of Close Fit (RMSEA < 0.05) = 0.00
Expected Cross-Validation Index (ECVI) = 4.91
90 Percent Confidence Interval for ECVI = (4.64 ; 5.19)
ECVI for Saturated Model = 1.62
ECVI for Independence Model = 181.81
Chi-Square for Independence Model with 465 Degrees of Freedom = 111205.60
Independence AIC = 111267.60
Model AIC = 3002.42
Saturated AIC = 992.00
Independence CAIC = 111435.57
Model CAIC = 3392.54
Saturated CAIC = 3679.51
Normed Fit Index (NFI) = 0.98
Non-Normed Fit Index (NNFI) = 0.98
Parsimony Normed Fit Index (PNFI) = 0.89
Comparative Fit Index (CFI) = 0.98
Incremental Fit Index (IFI) = 0.98
Relative Fit Index (RFI) = 0.97
Critical N (CN) = 114.48
Root Mean Square Residual (RMR) = 0.011
Standardized RMR = 0.035
Goodness of Fit Index (GFI) = 0.77
Adjusted Goodness of Fit Index (AGFI) = 0.73
Parsimony Goodness of Fit Index (PGFI) = 0.66
Time used: 0.234 Seconds
```

The results of the fitted model were further tested without including statements with a value of less than 0.500 to obtain the relationship between digital literacy, human resources in artificial intelligence, and the integration of artificial intelligence in education on the implementation of coding and artificial intelligence learning to support deep learning through teacher skills in coding and artificial intelligence based on Gemini Canvas as a mediator with standardized solution results as shown in Figure 4.

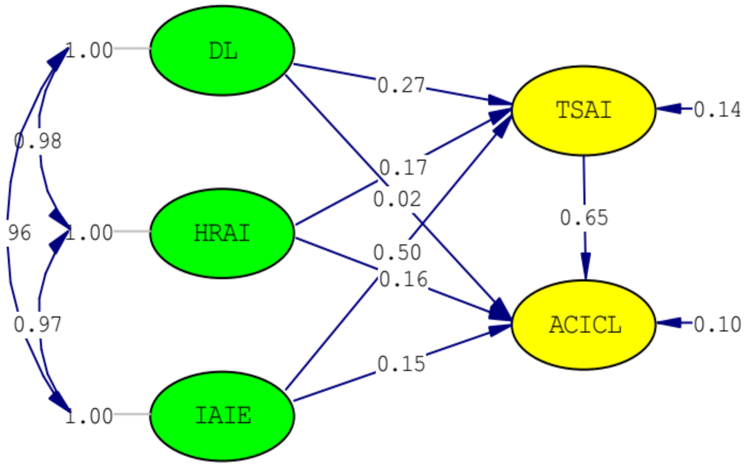


Fig. 4. Final Structural Equation Modelling (SEM) model results from Lirel 8.8

Confirmatory factor analysis (CFA) using the Lisrel application shows that the variables have causal relationships based on Figures 4 and 5, supported by the syntactic output results in the Lisrel application. The final SEM model in Figure 4 yielded the following results: the relationship between the variables of digital literacy, human resources in artificial intelligence, and the integration of artificial intelligence in education on the implementation of coding and artificial intelligence learning to support deep learning through teacher skills in coding and artificial intelligence based on Gemini Canvas. The hypothesis proposed at the beginning of this article is that teacher skills in coding and artificial intelligence based on Gemini Canvas act as a mediator. Based on the analysis and calculations of the model obtained from the Lisrel application in Figures 4 and 5, the model is consistent with the RMSEA (0.08) and NFI (0.98), indicating that the hypothesized relationship between the variables is supported by empirical data. Figure 5 illustrates digital literacy, human resources in artificial intelligence, and the integration of artificial intelligence in education in relation to the implementation of coding and artificial intelligence instruction to support the development of teachers' skills in coding and artificial intelligence based on the Gemini Canvas. For further details, see Figure 5.

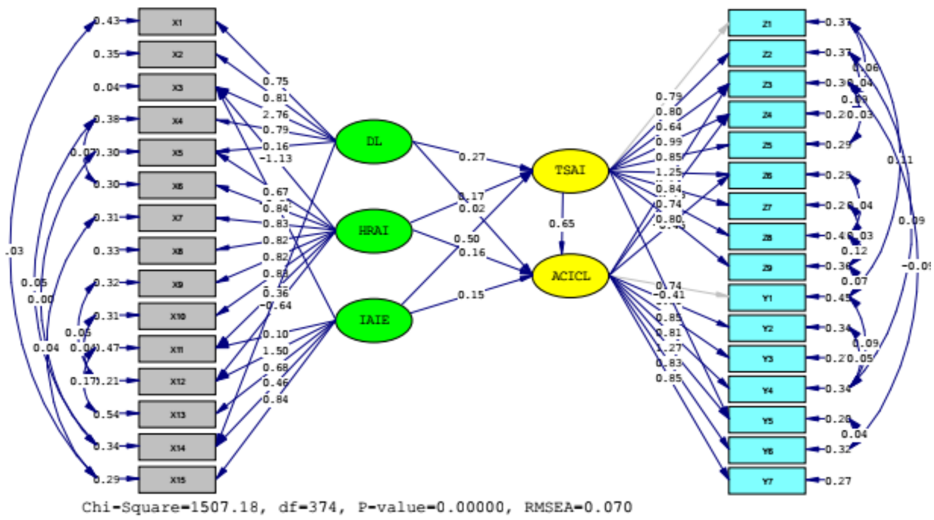


Fig. 5. Final Structural Equation Modelling (SEM) standard solution from Lirel 8.8

The results show the influence of the variable Teacher Skills in Coding and Artificial Intelligence based on Gemini Canvas (0.62) on the Implementation of Coding and Artificial Intelligence Learning in supporting deep learning and is influenced by the variables Digital Literacy (0.35), Human Resources in Artificial Intelligence (0.05), and the Integration of Artificial Intelligence in Education (0.54). The implementation of coding and artificial intelligence learning to support deep learning is directly influenced by the variables of digital literacy (0.08), human resources in artificial intelligence (0.17), and the integration of artificial intelligence in education (0.09) for 613 respondents. These results indicate that teachers' skills in coding and artificial intelligence based on Gemini Canvas act as mediators, as calculated in the goodness-of-fit statistical output in the Lisrel 8.8 application. The indirect effects on the variables of Digital Literacy (0.097), Human Resources in Artificial Intelligence (0.150), and Integration of Artificial Intelligence in Education (0.010).

The results of Figure 4 and Figure 5, correspond to the goodness of fit statistical output in the Lisrel 8.8 application below:

DATE: 8/13/2025
TIME: 17:43
L I S R E L 8.80
BY
Karl G. Jöreskog & Dag Sörbom
This program is published exclusively by
Scientific Software International, Inc.
7383 N. Lincoln Avenue, Suite 100
Lincolnwood, IL 60712, U.S.A.
Phone: (800)247-6113, (847)675-0720, Fax: (847)675-2140
Copyright by Scientific Software International, Inc., 1981-2006
Use of this program is subject to the terms specified in the
Universal Copyright Convention.
Website: www.ssicentral.com
The following lines were read from file H:\dataKKA\KKAanalisis1.spj:
Raw Data from file 'H:\dataKKA\KKAanalisis1.psf'
Sample Size = 613
Latent Variables DL HRAI IAIE TSAI ACICL
Relationships

X1-X5=DL
X6-X10=HRAI
X11-X15=IAIE
Z1-Z9=TSAI
Y1-Y7=ACICL
TSAI=DL HRAI IAIE
ACICL=DL HRAI IAIE
ACICL=TSAI
Set Error Covariance of Z4 and Z1 Free
Set Error Covariance of Z4 and Z2 Free
Set Error Covariance of Z4 and Z3 Free
Set Error Covariance of Z5 and Z3 Free
Set Error Covariance of Z8 and Z6 Free
Set Error Covariance of Z9 and Z7 Free
Set Error Covariance of Z9 and Z8 Free
Set Error Covariance of Y1 and Z1 Free
Set Error Covariance of Y1 and Z9 Free
Set Error Covariance of Y4 and Z2 Free
Set Error Covariance of Y4 and Y2 Free
Set Error Covariance of Y4 and Y1 Free
Set Error Covariance of Y6 and Y5 Free
Set Error Covariance of Y6 and Z3 Free
Set Error Covariance of Z6 and Z8 Free
Set Error Covariance of X4 and Z3 Free
Set Error Covariance of X3 and Y6 Free
Set Error Covariance of X2 and Z3 Free
Set Error Covariance of X4 and Z7 Free
Set Error Covariance of X5 and Y6 Free
Set Error Covariance of X7 and Y1 Free
Set Error Covariance of X7 and Y4 Free
Set Error Covariance of X6 and X4 Free
Set Error Covariance of X2 and Z7 Free
Set Error Covariance of X7 and Z2 Free
Set Error Covariance of X10 and Y7 Free
Set Error Covariance of X14 and X5 Free
Set Error Covariance of X14 and X4 Free
Set Error Covariance of X14 and Y5 Free
Set Error Covariance of X15 and Z2 Free
Set Error Covariance of X15 and Z4 Free
Set Error Covariance of X15 and Y4 Free
Set Error Covariance of X15 and X1 Free
Set Error Covariance of X15 and X7 Free
Set Error Covariance of X14 and Z4 Free
Set Error Covariance of X14 and Z5 Free
Set Error Covariance of X13 and X11 Free
Set Error Covariance of X13 and Y4 Free
Set Error Covariance of X13 and Y6 Free

Set Error Covariance of X12 and X10 Free
Set Error Covariance of X12 and X9 Free
Set Error Covariance of Z6 to ACICL Free
Set Error Covariance of Z3 to ACICL Free
Set Error Covariance of Z4 to ACICL Free
Set Error Covariance of Y5 to TSAI Free
Set Error Covariance of X3 to IAIE ree
Set Error Covariance of X14 to DL Free
Set Error Covariance of X3 to HRAI Free
Set Error Covariance of X5 to HRAI Free
Set Error Covariance of X11 to HRAI Free
Set Error Covariance of X12 to HRAI Free
Path Diagram
End of Problem
Sample Size = 613
LISREL Estimate (Maximum Likelihood)
Structural Equations
TSAI = 0.27*DL + 0.17*HRAI + 0.50*IAIE, Errorvar.= 0.14 , R² = 0.86
(0.11) (0.17) (0.13) (0.016)
2.57 0.96 3.83 8.91
ACICL = 0.65*TSAI + 0.018*DL + 0.16*HRAI + 0.15*IAIE, Errorvar.= 0.099 , R² = 0.90
(0.069) (0.087) (0.14) (0.11) (0.014)
9.44 0.20 1.12 1.36 7.23
Reduced Form Equations
TSAI = 0.27*DL + 0.17*HRAI + 0.50*IAIE, Errorvar.= 0.14, R² = 0.86
(0.11) (0.17) (0.13)
2.57 0.96 3.83
ACICL = 0.19*DL + 0.26*HRAI + 0.47*IAIE, Errorvar.= 0.16, R² = 0.84
(0.11) (0.17) (0.13)
1.80 1.52 3.60
Goodness of Fit Statistics
Degrees of Freedom = 374
Minimum Fit Function Chi-Square = 1604.44 (P = 0.0)
Normal Theory Weighted Least Squares Chi-Square = 1507.18 (P = 0.0)
Estimated Non-centrality Parameter (NCP) = 1133.18
90 Percent Confidence Interval for NCP = (1017.38 ; 1256.52)
Minimum Fit Function Value = 2.62
Population Discrepancy Function Value (F0) = 1.85
90 Percent Confidence Interval for F0 = (1.66 ; 2.05)
Root Mean Square Error of Approximation (RMSEA) = 0.070
90 Percent Confidence Interval for RMSEA = (0.067 ; 0.074)
P-Value for Test of Close Fit (RMSEA < 0.05) = 0.00
Expected Cross-Validation Index (ECVI) = 2.86
90 Percent Confidence Interval for ECVI = (2.67 ; 3.06)
ECVI for Saturated Model = 1.62
ECVI for Independence Model = 181.81
Chi-Square for Independence Model with 465 Degrees of Freedom = 111205.60

Independence AIC = 111267.60
Model AIC = 1751.18
Saturated AIC = 992.00
Independence CAIC = 111435.57
Model CAIC = 2412.22
Saturated CAIC = 3679.51
Normed Fit Index (NFI) = 0.99
Non-Normed Fit Index (NNFI) = 0.99
Parsimony Normed Fit Index (PNFI) = 0.79
Comparative Fit Index (CFI) = 0.99
Incremental Fit Index (IFI) = 0.99
Relative Fit Index (RFI) = 0.98
Critical N (CN) = 169.05
Root Mean Square Residual (RMR) = 0.0089
Standardized RMR = 0.030
Goodness of Fit Index (GFI) = 0.86
Adjusted Goodness of Fit Index (AGFI) = 0.82
Parsimony Goodness of Fit Index (PGFI) = 0.65
Time used: 0.438 Seconds

Eq. (2), Eq. (3) and Eq. (4) by entering the values in figure 5, and outputting goodness of fit statistics in lisrel 8.8. its application, for digital literacy variables (X1), human resources in artificial intelligence variables (X2), and integration of artificial intelligence in education varaibles (X3), the application of coding and artificial intelligence and coding in learning varaibles (Z) and teachers' skills in artificial intelligence coding based on gemini canvas varaibles (Y) becomes:

Structure 1:

$$Z = 0.27\ X1 + 0.17\ X2 + 0.50\ X3 + \delta \tag{5}$$

Structure 2:

$$Y = 0.19\ X1 + 0.26\ X2 + 0.47\ X3 + \delta \tag{6}$$

Structure 3:

$$Y' = 0.018\ X1 + 0.160\ X2 + 0.150\ X3 + 0.650\ Z + \delta \tag{7}$$

LISREL Estimation Structural Equation Calculation (Maximum Likelihood): digital literacy variables, human resources in artificial intelligence variables, and integration of artificial intelligence in education varaibles, the application of coding and artificial intelligence and coding in learning varaibles and teachers' skills in artificial intelligence coding based on gemini canvas. The results of structural Eq. (5) mean the application of coding and artificial intelligence and coding in learning influences digital literacy (32%), human resources in artificial intelligence (22%), and integration of artificial intelligence in education (48%). Confirmatory factor analysis (CFA) using SEM with its application makes it very easy to find causal relationships or relationships between two variables that influence each other, as seen in Figure 1 and Figure 2, supported by the LISREL Estimates (Maximum Likelihood) output. The results of the independent variable correlation matrix show that human resources in artificial intelligence is influenced by digital literacy variables by 0.98 with a t-value of 6.58. Integration of artificial intelligence in education variables is influenced by digital literacy by 0.96 with a calculated t value of 5.16 > 0.50, and integration of artificial intelligence in education is influenced by human resources in artificial intelligence by 0.97 by 0.50 with a t value of 7.77 > 0.50, which means the influence is significant.

The findings of this study indicate that the implementation of coding and artificial intelligence education is influenced by digital literacy, human resources in artificial intelligence, and the integration of artificial intelligence in education in supporting deep learning through teachers' skills in coding and artificial intelligence based on Gemini Canvas. This study reveals an important finding that the use of coding and artificial intelligence based on Gemini Canvas has a significant influence on the implementation of coding and artificial intelligence learning in supporting deep learning [34-36]. This research was conducted with the aim of evaluating the effectiveness of using Gemini Canvas-based coding and artificial intelligence to maximize the implementation of coding and artificial intelligence learning in supporting deep learning. These findings are based on empirical data collected through various methods, including observation, interviews, and analysis of digital literacy, teachers' competencies in coding and artificial intelligence, and the integration of coding and artificial intelligence in education before and after Gemini Canvas to support deep learning [14].

3.1.1 Teacher competence in coding and artificial intelligence

Some of the major challenges organizations face in managing talent in this field are (1) Talent Gap and Fierce Competition. There is a very high demand for AI professionals and skilled developers, but the supply is limited. This creates a highly competitive labor market, where companies compete to attract the best talent by offering high salaries and attractive benefits. The challenge is how to attract and retain this key talent from other companies, including innovative startups; (2) Rapidly Obsolete Skills AI Technology, Programming Languages, and Frameworks are Evolving at an Extraordinary Pace. A skill that is relevant today may become obsolete in a few years. Therefore, the HR challenge is to ensure employees continue to learn and update their skills continuously. This requires significant investment in training, upskilling, and reskilling, as well as creating an organizational culture that supports lifelong learning; (3) Team Management and Retention. AI teams and developers often have different work cultures and motivations. They tend to value autonomy, the opportunity to work on challenging projects, and the freedom to experiment. The challenge is how to create a work environment that is not only attractive but also retains them. This involves providing the right tools, meaningful projects, and a flexible management structure. Retention is crucial because the costs of recruiting and training new talent are extremely high.

Coding and AI [30] are the main pillars of innovation today, but the HR challenges in managing talent in this field cannot be underestimated. Successful organizations will be those that can identify, attract, train, and retain the best AI and coding talent through proactive and adaptive HR strategies.

In general, teacher competencies in Indonesia are categorized into four main areas: (1) Pedagogical Competencies [32]: A teacher's ability to manage learner-centered instruction. This aspect includes planning, implementing, and evaluating effective and safe learning experiences for students; (2) Personal Competencies: Teachers must possess a stable personality, high moral character, and authority and serve as role models. This aspect also includes the ability to reflect on oneself to improve the quality of teaching; (3) Professional Competence [10]: Broad and deep mastery of subject matter. This includes the ability to design learning objectives and organize knowledge content to facilitate student understanding; and (4) Social Competence [35]: The ability to communicate and interact effectively with students, fellow teachers, parents, and the surrounding community. Collaboration is a key element of this competency.

In the era of the Fourth Industrial Revolution and Society 5.0, the above competencies must be enriched with technological literacy [15]. The specific competencies required by teachers in Indonesia to master coding and AI include:(1) Conceptual Understanding: Teachers must understand the fundamentals of computational thinking, which is how to solve problems in the same way a computer does. This is the foundation of coding and AI; (2) Mastery of Tools and Languages: Ability to use visual coding tools such as Scratch JR for basic levels, as well as text-based programming languages such as Python for higher levels; (3) Application in the Classroom: Teachers must not only master the technical aspects but also be able to integrate coding and AI into the existing curriculum. The goal is for students to become creators, not just consumers of technology; and (4) Data Literacy: Understanding how data is collected, analyzed, and used in the context of AI. Teachers need to guide students in projects involving simple data analysis.

To keep pace with the demands of the times, teachers' competencies must be enhanced with mastery of coding and AI [21]. These competencies are not limited to technical knowledge but also include the ability to integrate technology into teaching methods. Technical skills and literacy include (1) computational thinking: teachers must understand the basic concepts of problem-solving in a logical and systematic way, which is at the core of coding; (2) Coding Literacy: Ability to use visual coding tools such as Scratch for elementary students and text-based programming languages such as Python for higher levels; (3) Data Literacy: Understanding how data is collected, analyzed, and used. Teachers need to guide students in simple projects involving data, as the foundation of AI; (4) Conceptual Understanding of AI: Understanding the basic principles of AI, such as machine learning, and the ethics that accompany it, in order to teach these concepts to students appropriately.

Pedagogical and Implementation Skills can be implemented through (1) Project-Based Learning: Teachers must be able to design activities where students use coding to solve real-world problems or create creative projects. This approach transforms students from consumers into creators of technology; (2) Digital Skills Assessment: Being able to evaluate students' understanding and skills in coding and AI and provide constructive feedback; and (3) Digital Collaboration: Being able to collaborate with fellow teachers or the technology community to develop best practices in teaching coding and AI.

With the introduction of a new curriculum that includes coding and AI as elective subjects, as announced by the Ministry of Education, Culture, Research, and Technology, the role of teachers has become increasingly important. They are no longer merely knowledge providers but rather facilitators and guides. Teachers must be able to help students develop systematic, creative, independent, and responsible thinking skills in using technology.

Coding is a fundamental process where we write a series of instructions in a programming language to command a computer to perform specific tasks. In essence, coding is the language used to “communicate” with machines. It is the foundation of all software, including the applications we use daily, operating systems, and even AI itself. Strong coding skills encompass logic, problem-solving, and algorithmic understanding.

Artificial Intelligence (AI), on the other hand, is a more advanced field where we create machines that can “think” or mimic human cognition [17]. AI doesn't just follow instructions; it can learn from data, recognize patterns, make decisions, and solve problems without being explicitly programmed for every scenario. Examples include recommendation systems on streaming platforms, voice assistants, and self-driving cars. Coding is the primary tool for building AI models, training them, and implementing them.

3.1.2 The Importance of artificial intelligence integration in education

AI integration [9] is crucial because it offers solutions to several fundamental problems in traditional education systems. AI has the ability to personalize learning in ways that were previously impossible. These include (1) adaptive and personalized learning. Every student has different learning speeds and styles. AI systems can analyze student performance in real-time and adjust learning materials, difficulty levels, and teaching methods according to individual needs. This ensures that every student receives the appropriate support, whether for enrichment or remediation; (2). Automation of Administrative Tasks. AI can automate time-consuming administrative tasks such as essay grading, scheduling, and attendance tracking. This frees up teachers' time so they can focus more on personal interactions with students, providing guidance, and developing more innovative curricula (3). Access to Global Learning Resources. AI can provide access to rich and diverse educational resources from around the world, transcending geographical boundaries. Examples include educational chatbots or virtual assistants that can answer students' questions 24/7, or AI-based language translation tools that enable cross-cultural collaboration. This bridges the education gap and provides equal opportunities for all.

3.1.3 Challenges in integrating artificial intelligence

Although important, implementing AI in education is not easy and faces several critical challenges, namely:(1). Digital Divide and Access. The biggest challenge is the digital divide. Not all schools or students have equal access to technology, hardware, and stable internet connections. Uneven AI integration can widen the gap between privileged and underprivileged students, creating inequality in education. (2). Teacher Training and Professional Development. Teachers are the key to the success of AI integration. However, many educators currently lack the necessary skills or understanding of how to effectively use AI in teaching. Insufficient professional development may result in AI tools not being utilized optimally or even being misused; (3). Data Privacy and Ethics. AI systems in education collect large amounts of data about students. This raises serious concerns about privacy, data security, and ethics. Who owns the data? How is it used? There is a risk that data could be used for commercial purposes or to create potentially biased student profiles. It is important to have a strict ethical framework in place to protect student data.

3.1.4 The importance of coding and artificial intelligence education

The implementation of coding and AI education is no longer just about preparing students for careers in technology but also equipping them with fundamental skills for a technology-driven future. The implementation of KKA includes: (1). Developing Critical and Logical Thinking Skills. Coding teaches students to solve problems in a structured and logical manner. The process of analyzing problems, breaking them down into smaller parts, and devising step-by-step solutions is at the core of computational thinking. These skills are highly relevant not only in programming but also in every aspect of life, from completing daily tasks to making complex decisions; (2). Preparing Students for the Future Economy

Almost every industry, from healthcare to the arts, is increasingly reliant on technology. Understanding coding and AI will give students a competitive edge in the ever-changing job market. They will not only be consumers of technology but also creators and innovators capable of leveraging these tools to solve real-world problems; (3). Fostering Creativity and Innovation. Coding and AI are tools for creativity. With a basic understanding, students can build applications, create games, design robots, or even develop AI models to predict outcomes. This encourages them to think outside the box and see technology as a means to realize their ideas;

3.1.5 Implementation strategies in classroom learning

Implementing coding and AI in the curriculum requires a planned and gradual approach, namely:(1) Graded Integration (Early Childhood to Middle School), including (a) Basic Level (Elementary School): Start with unplugged concepts that do not require computers, such as logic and algorithms through games and physical activities. Visual software like Scratch or Blockly is very effective for introducing the basics of coding without having to type code; (b) Intermediate Level (Middle School): Introduce simple text-based programming languages like Python. Focus on projects relevant to their interests, such as creating simple games or analyzing data. At this stage, AI concepts can be introduced through simple projects, such as training AI models to recognize images. (c) Advanced Level (High School): Coding can be applied in various subjects. For example, using coding to model physical processes, analyze statistical data, or create simulations. Here, more in-depth AI topics such as machine learning and deep learning can be taught, with a focus on practical applications and ethical implications; (2). Project-Based Learning Approach. Coding and AI learning should be active and project-based. Instead of just listening to theory, students should build something. For example, they could be asked to build an application that solves a problem at school, such as a scheduling system, or a simple robot programmed to perform a specific task. This approach makes learning more engaging, relevant, and meaningful; (3) Teacher Training. The most crucial strategy is to train teachers. Teachers must have a strong understanding of coding and AI and be able to integrate them into their curriculum. Schools must provide ongoing training, resources, and technical support to ensure educators feel confident teaching this material.

With the right strategies, we can ensure that future generations are not only prepared to face technological challenges but also capable of shaping the future with their creativity and intelligence.

3.1.6 Growth mindset in deep learning

In the context of education, a growth mindset is the belief that a person's abilities and intelligence are not fixed but can be developed through dedication, effort, and the right strategies. This is a very important psychological foundation for deep learning [19]. This mindset contrasts with a fixed mindset, in which a person believes that their abilities are innate and cannot be changed.

When students have a growth mindset, they view challenges as opportunities for growth rather than threats, are not afraid to make mistakes but see them as part of the learning process, value effort and perseverance as the path to mastery rather than just the final outcome, and are inspired by others' successes and use them as motivation [34].

This mindset is crucial because deep learning [20] requires students to step out of their comfort zone, confront complex ideas, and solve difficult problems. Without the belief that they are capable, students will tend to give up when faced with difficulties.

3.1.7 Principles and learning experiences for deep learning

Deep learning is an approach that encourages students to gain rich and comprehensive understanding, not just memorize facts. To achieve this, specific learning principles and experiences are needed, namely: (1) Active Learning: Students do not just sit and listen. They are directly involved in the learning process through discussions, simulations, and experiments; (2) Problem-Based Learning: Learning begins with an authentic, real-world problem or question that is interesting. Students then search for, analyze, and synthesize information to find solutions; (3) Collaborative Learning: Students work together in groups to solve problems. This develops communication skills, teamwork, and the ability to learn from other people's perspectives; (4) Constructive Feedback: Feedback is not only in the form of grades but also specific suggestions on how students can improve their work. This reinforces a growth mindset [5].

The principles of learning in deep learning [13] are conscious, meaningful, and enjoyable through the learning experience of understanding, applying, and reflecting. These principles create authentic learning experiences, where knowledge is actively constructed by students, not simply transferred by teachers. This is a shift from the role of the teacher as an information provider to that of a facilitator [12] and mentor [8].

3.1.8 Implementation in classroom learning

Integrating a growth mindset and deep learning [11] principles requires deliberate strategies. Here are some ways to implement them in the classroom:(1) Test Effort, Not Intelligence: Instead of saying, “You're so smart,” try saying, “That's amazing; you worked really hard to solve that problem.” This reinforces the idea that effort is the key to success; (2) Design Problem-Based Projects: Assign projects that challenge students to apply what they have learned to solve real-world problems. For example, ask them to design a recycling system for the school or create a campaign to reduce plastic use; (3) Implement Group Learning: Form study groups where students of varying ability levels can work together. This encourages them to teach and learn from one another; (4) Tolerance for Mistakes: Create a classroom environment where mistakes are seen as normal and a source of learning. Ask students to share their mistakes and what they learned from them; (5) Use Open-Ended Questions: Ask questions that do not have a single answer. This encourages deep and critical thinking [3].

By implementing these strategies, teachers not only teach subject matter but also cultivate the character and skills that are so necessary in the 21st century [22]. A growth mindset and student-centered learning [35] principles are a powerful combination for creating a generation of lifelong learners.

4. Conclusions

Artificial intelligence with Gemini Canvas is not just a complementary tool but a revolutionary pedagogical approach to teaching deep learning. Its use in the classroom can accelerate the learning curve and make complex topics more accessible and engaging for students.

By reducing the focus on tedious technical aspects and increasing direct interaction with AI models, Gemini Canvas can foster an intuitive understanding of AI principles. This is crucial for shaping the next generation of data scientists, AI engineers, and even individuals in other fields who need to understand the implications of AI. Therefore, AI with Gemini Canvas has great potential to transform how AI education is delivered, making it more collaborative, practical, and effective.

The implementation of learning as an approach that must be applied by teachers in Indonesia requires the use of digital technology in its application in the classroom. Teachers' competencies in coding and artificial intelligence are highly needed. By leveraging artificial intelligence through the Gemini Canvas application, classroom learning becomes more comfortable. Thus, the principles of conscious, meaningful, and enjoyable learning through experiences that involve understanding, applying, and reflecting can be easily implemented, leading to improved literacy skills—particularly digital literacy—among students in Indonesia, which can support improvements in PISA scores in future assessments. Further research can be conducted on the experiences of students and the school ecosystem when using artificial intelligence with Gemini Canvas.

Acknowledgement
This research was funded by the researcher's personal funds.

References
[1] Adu, Emmanuel O., and Sindiswa S. Zondo. "Enhancing teachers' digital skills in teaching of economics in south african secondary schools." *International Journal of Educational Research Open* 6 (2024): 100310. https://doi.org/10.1016/j.ijedro.2023.100310
[2] Arjaya, Ida Bagus Ari, I. Hermawan, and Anak Agung Inten Paraniti. "Metacognitive Contribution to Biology Pre-service Teacher's Digital Literacy and Self-Regulated Learning during Online Learning." *International Journal of Instruction* 16, no. 1 (2023). https://doi.org/10.29333/iji.2023.16125a
[3] Atan, Muhammad Haziq, Nurbaity Sabri, Nur Nabilah Abu Mangshor, Shafaf Ibrahim, Ahmad Firdaus Ahmad Fadzil, Hajar Izzati Mohd Ghazalli, Anis Amilah Shari, and Hartayuni Sain. 2024. "Automated Detection of Unattended Children via Deep Learning." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 62 (3): 11–20. https://doi.org/10.37934/araset.62.3.1120
[4] Bøe, Marit, Johanna Heikka, Titta Kettukangas, and Karin Hognestad. "Pedagogical leadership in activities with children–A shadowing study of early childhood teachers in Norway and Finland." *Teaching and Teacher Education* 117 (2022): 103787. https://doi.org/10.1016/j.tate.2022.103787
[5] Canaday, Sara. 2023. *Coaching Essentials for Managers*. Mc Graw Hill. Mc Graw Hill.
[6] Chigisheva, Oksana, Elena Soltovets, Anna Dmitrova, Anna G. Akhtyan, Svetlana N. Litvinova, and Yuliya V. Chelysheva. "Digital literacy and its relevance to comparative education researchers: Outcomes of SciVal analytics." *Eurasia Journal of Mathematics, Science and Technology Education* 17, no. 10 (2021): em2017. https://doi.org/10.29333/ejmste/11183
[7] Creswell, John W., and J. David Creswell. 2023. *Research Design: Qualitatif, Quantitative, and Mixed Methods Approaches*. Sage.
[8] Downey, Myles. 2009. *Effectiive Modern Coaching: The Principles and Art of Succesfull Business Coaching*. LID Publishing.
[9] Francis, Bakare Shola, Azlan Abdul Latib, Evarina Amiron, Kamalularifin Subari, and Yusri Kamin. "Measuring the Importance of Non-Technical Skills for Integration into Metalwork Technology Curriculum Using Structural Equation Modelling." *International Journal of Instruction* 13, no. 3 (2020): 317-328. https://doi.org/10.29333/iji.2020.13322a
[10] Hammer, Sabine, and Stefan Ufer. "Professional competence of mathematics teachers in dealing with tasks in lesson planning." *Teaching and Teacher Education* 132 (2023): 104246.https://doi.org/10.1016/j.tate.2023.104246
[11] Heruatmadja, Chandra Hermawan, Harjanto Prabowo, H. Leslie Hendric Spits Warnar, and Yaya Heryadi. "Warehouse Technology Revolution: Integration of Drones and Deep Learning Algorithms for Stock Identification and Calculation Automation.". https://doi.org/10.37934/araset.64.4.7490
[12] Imron, Imron, Suwito Eko Pramono, Ani Rusilowati, Sulhadi Sulhadi, and Achmad Samsudin. "Analysis of the Use of Polypad-Based Educational Media on Mathematics Teacher Competencies in Indonesia: A Structural Equation Modelling (SEM) Approach." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 53, no. 1 (2025): 16-31.https://doi.org/10.37934/araset.53.1.1631
[13] Islam, Fahadul, Md Shohel Arman, Ong Bi Lynn, Hasnur Jahan, R Badlishah Ahmad, Naimah Yaakob, Nur Farhan Kahar, and Md Maruf Hassan. 2026. "Parking Slot Detection and Vacancy Check Based on Deep Learning Method." *Journal of Advanced Research in Applied Sciences and Engineering Technology Journal Homepage* 60: 155–72. https://doi.org/10.37934/araset.60.3.155172
[14] Jenie, Renan Prasta, Rina Adibah, Arga Aridarma, Sri Kristiana Rahayu, Muhammad Dahrul, Irzaman Irzaman, and Husin Alatas. 2025. "Inference of FTIR Characterization Results of Human Blood Glucose Levels Using Artificial Neural Network (ANN)." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 64 (2): 1–9. https://doi.org/10.37934/araset.64.2.119
[15] Juandi, Tarpin, Ida Kaniawati, Achmad Samsudin, and Lala Septem Riza. "Virtual Laboratory and Artificial Intelligence in Science Education: Bibliometric Analysis Based on Scopus Source." *Journal of Advanced Research in Applied Sciences and Engineering Technology* (2024): 103-123. https://doi.org/https://doi.org/10.37934/araset.59.3.129149
[16] Leavy, Patricia. 2017. *Research Design: Quantitative, Qualitative, Mixed Methods, Arts-Based, and Community-Based Participatory Research Approaches*. The Guilford Press.
[17] Madli, Faerozh, Yuzainy Janin, Salleh Wahab, Dean Nelson Mojolou, Masran Tamin, Adi Jafar, Ag Kaifah, et al. 2026. "The Intersection of Artificial Intelligence, Marketing, and Cancer Awareness: A New Synthesis for Future

Leverage." *Journal of Advanced Research in Applied Sciences and Engineering Technology Journal Homepage* 59: 173–83. https://doi.org/10.37934/araset.59.3.173183

[18] Mahalingam, Gopal R., Norazrena Abu Samah, Baanurekha K. Ravihchandran, Khairul Anuar Abdul Rahman, Dayana Farzeeha Ali, Abdul Halim Abdullah, Zakiah Mohamad Ashari, and Nurul Farhana Jumaat. "Need-analysis of interactive games of reading literacy for slow learners." *Universal Journal of Educational Research* 7, no. 12A (2019): 101-108. https://doi.org/10.13189/ujer.2019.071913

[19] Mat Leh, Nor Adni, Mohammad Nizam Ibrahim, Muhammad Khusairi Osman, Anuar Mohamad, and Mohd Najib Mohd Hussain. 2024. "A Review on Time Series Data Augmentation Techniques for Deep Learning." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 62 (3): 139–50. https://doi.org/10.37934/araset.62.3.139150

[20] Md Lazam, Nor Azlinah, AbuJalambo Mahmoud I M, Barhoom Alaa M A, Nur Erlida Ruslan, Shadi M S Hilles, and Samy S. Abu-Naser. 2025. "Spine Tumor Segmentation Using Deep Learning: A Review." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 63 (1): 271–98. https://doi.org/10.37934/araset.63.1.271298

[21] Md Nasir, Suraya, Mohd Ekram Al Hafis Hashim, Chee Ken Nee, Nor Hazlen Kamaruddin, Wandah Wibawanto, and Muhammad Luqman Hakim Mohd Hanapiah. 2026. "Enhancing Student Engagement in Learning Management Systems through Exploration of Avatars in Virtual Classrooms: A Systematic Review." *Journal of Advanced Research in Applied Sciences and Engineering Technology Journal Homepage*: Jurusan Seni Rupa 61 (4): 186–99. https://doi.org/10.37934/araset.61.4.186199

[22] Khalid, Mohd, Nor Hafizi, Adibah Abdul Latif, Megat Zakaria, Megat Aman Zahiri, Ibnatul Jalilah Yusof, and Md Daud Md Jani. "Identification of Constructs and Subconstructs of Teacher Classroom Assessment Literacy Instrument." *Pertanika Journal of Social Sciences & Humanities* 31, no. 2 (2023). https://doi.org/10.47836/pjssh.31.2.11

[23] Murni Hanum Md Ariff, Siti, Norlela Ishak, and Mazidah Tajjudin. 2026. "IoT-Based and Teachable Machine Platform for Covid-19 Prevention and Control." *Journal of Advanced Research in Applied Sciences and Engineering Technology Journal Homepage* 56: 165–84. https://doi.org/10.37934/araset.56.2.165184

[24] Nor Hashim, Nor Shuradi, Mohd Kipli Abdul Rahman, Muhamad Faisal Ahmad, Amsalib Pisali, and Dwiyana Habsary. 2025. "A Review on Integrating Digital Technologies into Teaching and Learning Activity: Engaging Street Children in Interactive Learning." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 56 (1): 80–96. https://doi.org/10.37934/araset.56.1.8096

[25] OECD. 2023. *PISA 2022 Results (Volume I).* I. PISA. OECD. https://doi.org/10.1787/53f23881-en.

[26] Ozden, Sule Yilmaz, Hui Yang, Huijing Wen, and Valerie Harlow Shinas. "Reflections from a teacher education course built on the TPACK framework: Examining the impact of the technology integration planning cycle on teacher candidates' TPACK development and practice." *Social Sciences & Humanities Open* 9 (2024): 100869. https://doi.org/10.1016/j.ssaho.2024.100869

[27] Palanichamy, Naveen, Ranjani Tamil Chelvan, Su Cheng Haw, Ng Kok Why, and Subhashini Gopal. 2025. "A Comparative Study of Deep Learning-Based Segmentation and Classification Techniques for Melanoma Detection." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 63 (1): 206–24. https://doi.org/10.37934/araset.63.1.206224

[28] Palanichamy, Naveen, Su Cheng Haw, Revathi K, Kok Why Ng, and Suthent Tamilselvam. 2025. "Emotion Recognition with Multi Physiological Signals: A Deep Learning Approach." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 63 (1): 188–205. https://doi.org/10.37934/araset.63.1.188205

[29] Roslan, Nuur Alifah, Maya Silvi Lydia, and Adnan Gutub. 2025. "Enhancing Secure QR Code Steganography through Artificial Intelligence: A Conceptual Framework." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 62 (4): 224–31. https://doi.org/10.37934/araset.62.4.224231

[30] Safriana, Safriana, Ade Irfan, Mutammimul Ula, Dwi Iramadhani, Zahratu Fitri, and Wan Zuki Azman Wan Muhamad. 2025. "Design Smart Teacher AI Application to Support Differentiated Learning in Science." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 63 (2): 137–47. https://doi.org/10.37934/araset.63.2.137147

[31] Sujarweni, V. Wiratna. 2018. *Panduan Mudah Olah Data: Struktural Equation Modelling (SEM) dengan Lisrel*. Pustaka Baru Pers. Vol. 1.

[32] Mardapi, Djemari, and Tutut Herawan. "Community-based teacher training: Transformation of sustainable teacher empowerment strategy in Indonesia." *Journal of teacher education for sustainability* 21, no. 1 (2019): 48-66.. https://doi.org/10.2478/jtes-2019-0004

[33] Tao, Chen, Mohamed Razeef, and Abd Razak. 2026. "The Application of Artificial Intelligence-Assisted Technology in Packaging Design of Agricultural Products." *Journal of Advanced Research in Applied Sciences and Engineering Technology Journal Homepage* 60: 1–14. https://doi.org/10.37934/araset.60.3.114

[34] Thomas, Asha, and Vikas Gupta. "Social capital theory, social exchange theory, social cognitive theory, financial literacy, and the role of knowledge sharing as a moderator in enhancing financial well-being: from bibliometric analysis to a conceptual framework model." *Frontiers in psychology* 12 (2021): 664638.https://doi.org/10.3389/fpsyg.2021.664638

[35] Tsai, Cheng-An, Mei-Yi Winnie Song, Yen-Fen Lo, and Chiung-Chuan Lo. "Design thinking with constructivist learning increases the learning motivation and wicked problem-solving capability—An empirical research in Taiwan." *Thinking Skills and Creativity* 50 (2023): 101385. https://doi.org/10.1016/j.tsc.2023.101385

[36] Verak, Nutveesa, Phaklen Ehkan, Ruzelita Ngadiran, Suwimol Jungjit, Siraya Sitthisarn, Mohd Nazri Mohd Warip, Mohd Zaizu Ilyas, and Fazrul Faiz Zakaria. 2025. "Comparative Analysis of ELM-Based Blind Image Quality Assessment with K-Fold Cross-Validation." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 64 (4): 213–22. https://doi.org/10.37934/araset.64.4.213-222

[37] van der Wilt, Femke, Renske Bouwer, and Chiel van der Veen. "Dialogic classroom talk in early childhood education: The effect on language skills and social competence." *Learning and Instruction* 77 (2022): 101522. https://doi.org/10.1016/j.learninstruc.2021.101522