Acta Scientiarum

http://periodicos.uem.br/ojs
ISSN on-line: 2178-5201
https://doi.org/10.4025/actascieduc.v47i1.72815

Multi-group analysis of willingness to integrate AI Chatbots in teaching and learning of physics

Wasiu Olayinka Yahaya*, Abdulrasaq Oladimeji Akanbi and Abdulkadir Aishat Yusuf

Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Kwara State, Nigeria. *Author for correspondence. E-mail: yahaya.wo@unilorin.edu.ng

ABSTRACT. The integration of artificial intelligence chatbots/technologies into teaching-learning process improves students' learning outcome and reduces teachers' pedagogical stress in classroom. The present study focused on the In and Pre-service physics teachers' willingness to integrate AI Chatbots in teaching and learning of physics. 45 In-service and 55 Pre-service physics teachers were engaged in the study. Attitude towards AI and Technology Readiness Index' components were correlated with their willingness to integrate AI Chatbots in teaching. Three research instruments were adapted and used to elicit information from the respondents. Partial Least Square of Structural Equation Model (PLS-SEM) was employed and the data collected were analyzed using SmartPLS software version 4.0.9.2. The multi-group analysis of the In and Pre-service physics teachers were run separately and together to determine the difference in the willingness to integrate AI Chatbots in teaching-learning process. The findings of the study revealed that the affective, behavioural and cognitive components of the attitude towards AI significantly correlated with the respondents' willingness to integrate AI Chatbots in teaching-learning process. The study concluded that attitude towards AI influences their willingness to integrate AI Chatbots to teaching-learning process.

Keywords: Artificial intelligence; attitude towards ai; technology readiness index; ai chatbots; teaching-learning and physics.

Análise multigrupo da disposição de integrar Chatbots de IA no ensino e aprendizagem de física

RESUMO. A integração de chatbots/tecnologias de inteligência artificial no processo de ensino-aprendizagem melhora o resultado de aprendizagem dos alunos e reduz o estresse pedagógico dos professores em sala de aula. O presente estudo centrou-se na vontade dos professores de física em exercício e em formação em integrar IA Chatbots no ensino e aprendizagem de física. 45 professores de física em serviço e 55 professores de física em formação foram envolvidos no estudo. Os componentes da atitude em relação à IA e ao Índice de Prontidão Tecnológica foram correlacionados com a sua vontade de integrar Chatbots de IA no ensino. Três instrumentos de pesquisa foram adaptados e utilizados para extrair informações dos entrevistados. Foi empregado o Modelo de Mínimos Quadrados Parciais de Equações Estruturais (PLS-SEM) e os dados coletados foram analisados no software SmartPLS versão 4.0.9.2. A análise multigrupo dos professores de física em formação e em formação inicial foi realizada separadamente e em conjunto para determinar a diferença na disposição de integrar AI Chatbots no processo de ensino-aprendizagem. As conclusões do estudo revelaram que os componentes afetivos, comportamentais e cognitivos da atitude em relação à IA correlacionaram-se significativamente com a vontade dos entrevistados em integrar os Chatbots de IA no processo de ensino-aprendizagem. O estudo concluiu que a atitude em relação à IA influencia a sua vontade de integrar AI Chatbots no processo de ensino-aprendizagem.

Palavras chave: Inteligência Artificial; atitude em relação à IA; índice de prontidão tecnológica; chatbots de IA; ensino-aprendizagem e física.

Análisis multigrupo de la disposición a integrar Chatbots de IA en la enseñanza y el aprendizaje de la física

RESUMEN. La integración de tecnologías y chatbots de inteligencia artificial en el proceso de enseñanza-aprendizaje mejora el resultado del aprendizaje de los estudiantes y reduce el estrés pedagógico de los

profesores en el aula. El presente estudio se centró en la voluntad de los profesores de física en formación y en formación de integrar chatbots de IA en la enseñanza y el aprendizaje de la física. En el estudio participaron 45 profesores de física en servicio y 55 en formación. La actitud hacia la IA y los componentes del Índice de preparación tecnológica se correlacionaron con su voluntad de integrar AI Chatbots en la enseñanza. Se adaptaron y utilizaron tres instrumentos de investigación para obtener información de los encuestados. Se empleó el modelo de mínimos cuadrados parciales de ecuaciones estructurales (PLS-SEM) y los datos recopilados se analizaron utilizando el software SmartPLS versión 4.0.9.2. El análisis multigrupo de los profesores de física en servicio y en formación se realizó por separado y en conjunto para determinar la diferencia en la voluntad de integrar AI Chatbots en el proceso de enseñanza-aprendizaje. Los hallazgos del estudio revelaron que los componentes afectivo, conductual y cognitivo de la actitud hacia la IA se correlacionaban significativamente con la voluntad de los encuestados de integrar AI Chatbots en el proceso de enseñanza-aprendizaje. El estudio concluyó que la actitud hacia la IA influye en su voluntad de integrar los Chatbots de IA al proceso de enseñanza-aprendizaje.

Palavrasclave: Inteligencia Artificial; actitud hacia la IA; índice de preparación tecnológica; chatbots de IA; enseñanza-aprendizaje y física.

Received on July4, 2024.
Accepted on October29, 2024.
Published in October 22, 2025.

Introduction

Artificial intelligence technologies (chatbots) in modern day teaching and learning remains one of the latest challenges for policy makers in education (Mageira et al., 2022). The introduction of new AI chatbots to the teaching-learning process has the potential of transforming it to modern way of knowledge dissemination, communication and acquisition (Adiguzel et al., 2023).

The integration of chatbots and technologies into teaching and learning is the most groundbreaking innovations in the e-learning field which enabled the development and bring about efficient and innovative solutions to major teaching-learning problems (Fernoaga et al., 2018). Gonda and Chu (2019) asserted that chatbots like Google dialog flow chatbot can be integrated into offline and online content to solve the challenges in teaching activities. Liu et al. (2022) opined that AI chatbots improves students' thinking ability, learning and knowledge acquisition skills and expectations in higher education.

Dimitriadis (2020) concluded that chatbots technology offers numerous services toward personalized and adaptive learning and by extension, it can also serves as virtual teaching assistants by relieving teacher of repetitive tasks. P et al. (2021) submitted that chatbots technology can address the diversified and logistics issues in teaching-learning process as faced by teachers and students in normal class which can also integrated into online platforms. Prananta et al. (2023) asserted that the use of ChatGPT in education offers opportunities in science learning, media and support and improves knowledge management.

Riza et al. (2023) advocated that inclusion of AI chatbots in e-learningprovide personalized service though with potential benefits and obstacles. Higher education students seems to be getting more comfortable with the usage of AI chatbots for learning due to their perceived convenience and enhanced performance (Malik et al., 2021). Every sector depends greatly on information and communication technology due to its efficient and effectiveness in service delivery with growing and acceptance of artificial intelligence in the field of ICT. The introduction of AI chatbots can enhance student learning experience in higher education, improve their productivity, aid their communication and also assist them in knowledge acquisition skills (Sandu & Gide, 2019).

Lin et al. (2023) highlighted the importance of chatbots to includes the provision of instant and automated responses and also improve students' performance during the learning cycle. The future of science teaching and learning especially mathematics and mathematics-oriented subjects/courses will involve personalized learning experience, blended learning environment, data's collection, organization and management literacy, computational thinking and statistics through the integration of artificial intelligence tools for thoughtful implementation and professional development (Supriyadi & Kuncoro, 2023).

A study conducted by Durak and Onan (2023) was centered on examination of research on the use of AI chatbots technology in the field of education. The authors considered 19 researched reports and papers that were related to AI chatbots technology in Google scholar. The analysis of study focused on article subject matter, purpose, research method, discussion and recommendation. The result of the study revealed that most of the studies were focused on the use of chatbots that were integrated into telegram,

WhatsApp, Slack and Facebook. The finding further shows that most of analyzed articles were carried out at higher education institutions. West (2023) carried out a search on AI-ChatGPT chatbots versions 3.5 and 4.0 and understanding of force concept inventory in an introductory physics course. The results from concluded that AI-ChatGPT chatbot responded to force concept inventory questions exactly physicist might answer the question.

The present study assessed the In-service and Pre-service physics teachers' attitude toward artificial intelligence (exogenous variable having three first order constructs), technology readiness index (exogenous variable having four first order construct) and willingness to integrate AI physics enabled chatbots in the teaching and learning processes (endogenous variable) as shown in Figure 1.

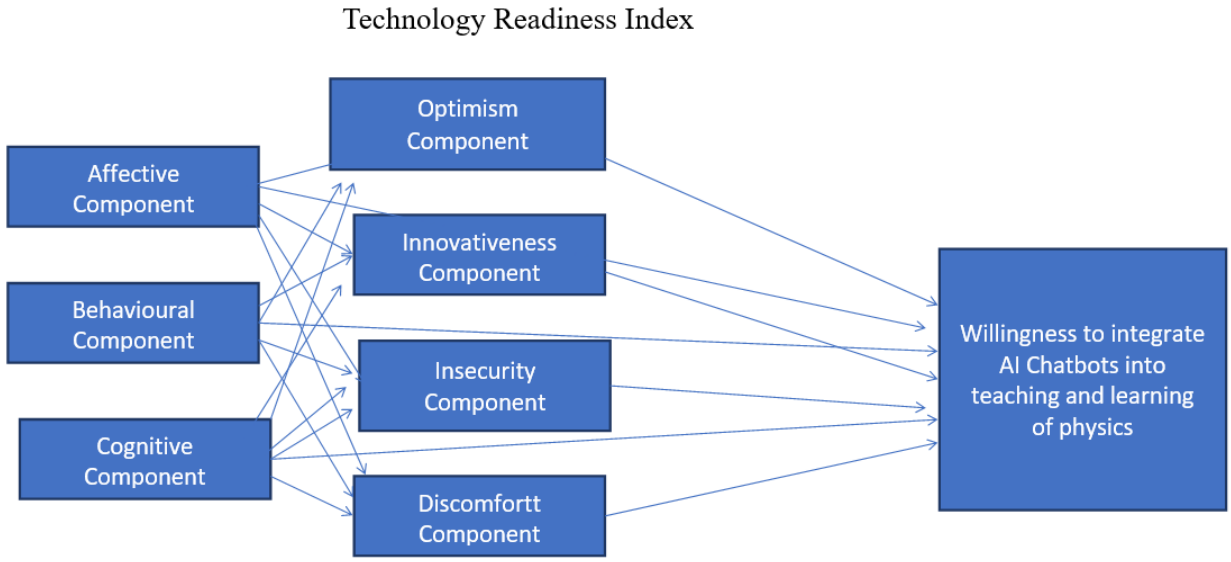

Figure 1. Attitude towards AI and Technology Readiness Index Framework.

Literature review and development of research hypotheses

The studies reviewed in this study were on previous empirical and systematic reviews' reports and findings on attitude towards artificial intelligence and technology readiness index.

Attitude towards artificial intelligence

Suh and Ahn (2022) developed and validate a model and its measuring scales of attitude toward artificial intelligence. The scholars believes that attitude of student toward artificial intelligence determine the adoption and willingness to integrate it into teaching and learning processes. This model as developed and validated by the scholars were carried out using confirmatory and exploratory factor analysis and it comprises of three main constructs (Behavioural component, Cognitive component and Affective component) with items and scale that can be adopted and adapted to measure them.

Chiu et al. (2021) posited that perceptions of AI's cognitive and operational capabilities positively relate to affective and cognitive attitudes. Schepman and Rodway (2020) asserted that general attitudes towards AI can be predicted through individual comfortableness with specific applications and latest technologies.

The component of human attitude on how to acts or behave towards an object, issue and situation is well described as a behavioral component of an attitudes. Wolf et al. (2020) asserted that attitude comprises of cognitive, affective and behavioural components that explains the cognitions, belief and emotional reactions, interest and interest of present and past actions. Conner et al. (2020) opined that inconsistency in cognitive and affective component of an attitude serves as overall determinant of behaviour.

HO_1. Behavioural, Cognitive and Affective components of attitude towards AI significantly related to willingness to integrate AI physics enabled chatbots into teaching-learning process;

Technology readiness index

Blut and Wang (2019) asserted that technology readiness index as a two-dimensional construct (motivator and inhibitor) indirectly influence the use of technology through technology acceptance model and quality-

value-satisfactions chain. Parasuraman and Colby (2015) opined that the recent streamlined and update in technology readiness index tagged technology readiness index (TRI 2.0) is a valid, reliable and can be useful in measuring people's willingness to embrace and use cutting edge technologies like AI.

Parasuraman (2000) developed a model tagged technology readiness index with the scholar thought of its essential roles the model plays in marketing service. Individual' s readiness to make use of new technologies can be measured by technology readiness index. This model is a two-dimensional construct which involves the motivator and inhibitor. The motivator construct of technology readiness index is divided into optimism and innovativeness. The optimism parts of technology readiness index work on the positive point of view of the respondent about the latest technology like AI tools and chatbots which make learning more effective. The innovativeness part of technology readiness index's motivator explains the likelihood of an individual to adopt latest technologies. The second construct of the technology readiness index named inhibitor which is also divided into discomfort and insecurity. The insecurity construct of technology readiness index' inhibitor explains the concern and risks latest technologies users been exposed to. These risks involve privacy infringement, security and general distrust of technology. The discomfort construct explains problems that may arise as a result of being overwhelmed by latest technologies.

Barkirtas and Akkas (2020) concluded that optimism construct of technology readiness index has a positive relationship on both consumer's perceived usefulness and perceived ease of use while innovativeness construct has positive relationship with consumer's perceived ease of use. Jarrar et al. (2020) concluded in a study sought to determine the technology readiness index's effect on the adoption of InDubai application, that the motivator constructs (optimism and innovativeness) as modelled by Parasuraman can prove the individual intentions to adopt latest technologies while the inhibitor (insecurity and discomfort) can hinder the adoption of latest technologies.

In another study conducted by Julian and Dhini (2022), the result of the study revealed that optimism, innovativeness and discomfort components of technology readiness index significantly influenced the perceived ease of use and perceived usefulness of smartwatch use.

HO_2. Behavioural, Cognitive and Affective component of attitude towards AI significantly related to optimism (motivator) component of technology readiness index;

HO_3. Behavioural, Cognitive and Affective component of attitude towards AI significantly related to innovativeness (motivator) component of technology readiness index;

HO_4. Behavioural, Cognitive and Affective component of attitude towards AI significantly related to discomfort (inhibitor) component of technology readiness index;

HO_5. Behavioural, Cognitive and Affective component of attitude towards AI significantly related to insecurity (inhibitor) component of technology readiness index;

HO_6. Optimism, Innovativeness, Discomfort and Insecurity components of technology readiness index significantly related to willingness to integrate AI Chatbots in teaching-learning process.

Research question

RQ_1. Does difference exist in relationship between in and pre-service physics teachers' attitude towards AI and willingness to integrate AI physics enabled chatbots in teaching-learning process?

RQ_2. Which of the attitude towards AI and Technology readiness index mostly predict the respondents' willingness to integrate AI physics enabled chatbots in teaching-learning process?

Method and measurement

The study uses the primary data gathered through face-to-face questionnaire administration to the respondents (pre-service and in-service physics teachers) that cut across the teachers' training college and teachers' training faculty at university and physics teachers who graduated, employed and engaged to teach at secondary school level in the last five years. The choice of the respondents was based on the fact that the popularity of artificial intelligence technologies/ tools/chatbots usage among the students is on the high sides in the last few years. According to Wikipedia, the investment and interest in AI gain momentum and popularity when machine learning tools were launched and adopted to solve many problems associated with academics, health, engineering, business and security. Modern correlation method was adopted to determine the complex relationship among attitude towards artificial intelligence model, technology readiness index model and willingness to integrate AI chatbots into teaching and learning process. In determine the variables relationship, influence and impact, the existing model of

technology readiness index by Parasuraman (2020) with four constructs (optimism, innovativeness, discomfort and insecurity), attitude towards artificial intelligence model by Suh and Ahn (2022) with three constructs (Behavioural, Cognitive and Affective) were adopted and willingness to integrate AI chatbots into teaching-learning process. The constructs' items were described in the Table 1. The variables involved in this study is complex and the modern relationship method known as structural equation model and machine learning were adopted in this study. The data collected were analyzed based on variables' relationship and importance performance. SmartPLS version 4.0.9.2 software was used to determine the relationship among variables and Artificial Neural Network (ANN) algorithm of machine learning embedded in SPSS software was used to determine the importance performance of the exogenous variables to willingness to integrate AI physics enabled Chatbots in teaching-learning process.

Table1. Construsts' Description.

Second Order Latent Variable	First/Higher Order Latent Variable	Construct's Meaning	Items' Code	Construct's Items	Validity Index	Source
Attitude towards AI		Thinking or feeling about AI	BE1	It is fun to learn about AI		
	Behavioural Component		BE2	It is interesting to use AI	>0.75	Items adapted from Suh and Ahn (2022)
			BE3	I want to make something that makes human life more convenient		
			BE4	I think that there should be more class time devoted to AI in school		
	Cognitive Component		COG1	I think it is important content to learn about AI in school		
			COG2	I think that AI should be taught in school	>0.75	Items adapted from Suh and Ahn (2022)
			COG3	I think every student should learn about AI in school		
			COG4	AI class is important		
	Affective component		AFF1	AI is related to my life		
			AFF2	I will use AI to solve problems in daily life	>0.75	Items adapted from Suh and Ahn (2022)
			AFF3	AI is worth studying		
			AFF4	AI is very important for developing society		
Technology Readiness Index		Readiness to exploit opportunities' offered by latest technology	OPT1	Technology gives me more freedom of mobility	>0.75	Items adapted from Parasuraman (2000)
	Optimism (Motivator)		OPT2	Technology gives people more control over their daily life		
			OPT3	Technology makes me more efficient in my occupation and study		
			OPT4	I feel confident that technology-based systems will follow through with what I instruct them to do		
			INN1	Learning about technology can be as rewarding as the technology itself		
	Innovativeness		INN2	I enjoy the challenge of	>0.75	Items adapted

	(Motivator)		figuring out high-tech gadgets		from Parasuraman (2000)
		INN3	I keep up with the most available advanced technology		
		INN4	Other people come to me for advice on new technologies		
		DIS1	I have fewer problems than other people in making technology work for me		
	Discomfort (Inhibitor)	DIS2	Sometimes, I think that technology systems are not designed for use by ordinary people	>0.75	Items adapted from Parasuraman (2000)
		DIS3	Technology always seems to fail at the worst possible time		
		DIS4	Many technologies have health or safety risks		
	Insecurity (Inhibitor)	INS1	I worry that information I make available over internet maybe misused by others	>0.75	Items adapted from Parasuraman (2000)
		INS2	I do not consider it safe to provide personal information over the internet		
		INS3	New technologies make it too easy to spy		
Willingness to integrate AI physics chatbots to teaching-learning process	The state of being prepared and ready to use AI chatbots for teaching and learning	WILL1	I am willing to use physics Chatbots in classroom		
		WILL2	I will recommend that others should use AI physics Chatbots in classroom	>0.75	Items adapted from Chatterjee and Bhattacharjee (2020)
		WILL3	I am willing to use AI technology for developing physics content for teaching-learning process		

Demographic profile of the respondents

The Table 2 described the demographic profiles of the respondents. 100 respondents were engaged to participate in this study and were selected through non-probability sampling technology (Purposive Sampling). The choice of the respondents was necessitated by their access to smart phone, ICT gadgets and internet network. 19 respondents representing 19% were female while 81 respondents representing 81% were male. The categories of the respondents involve 45 in-service physics teachers representing 45.0% of the total respondents' size and 55 pre-service physics teachers representing 55.0%.

Table 2. Demographic Profile of the Respondents.

Gender		N	%
	Female	19	19
	Male	81	81
	Total	100	100
Categories of the Respondents			
	Pre-Service Physics Teacher	55	55.0
	In-Service Physics Teachers	45	45.0
	Total	100	100

Results and findings

Measurement model

In this context, the values in matrix format represent the HTMT ratio which is used to evaluate the extent to which the each construct discriminates from other constructs in the formed model as shown Tables 3, 4, and 5.

Heterotrait-monotrait (HTMT) of correlations of the constructs' (discriminant validity)

Table 3. Complete table for both In and Pre-service physics teachers' responses on constructs in the model.

			Complete				
Construct	A	B	C	D	E	F	G	H
A								
B	0.516							
C	0.774	0.823						
D	0.371	0.155	0.224					
E	0.605	0.225	0.389	0.682				
F	0.094	0.035	0.083	0.769	0.232			
G	0.816	0.457	0.635	0.469	0.771	0.139		
H	0.172	0.353	0.106	0.128	0.172	0.226	0.178	

Table 4. Complete table for both In -service physics teachers' responses on constructs in the model.

			In-service				
Construct	A	B	C	D	E	F	G	H
A								
B	0.543							
C	0.778	0.885						
D	0.306	0.165	0.169					
E	0.589	0.201	0.350	0.609				
F	0.059	0.067	0.022	0.760	0.134			
G	0.837	0.469	0.632	0.423	0.748	0.049		
H	0.180	0.351	0.112	0.162	0.177	0.229	0.130	

Table 5. Complete table for both Pre-service physics teachers' responses on constructs in the model.

			Pre-service				
Construct	A	B	C	D	E	F	G	H
A								
B	0.503							
C	0.769	0.739						
D	0.456	0.156	0.293					
E	0.625	0.273	0.445	0.778				
F	0.236	0.058	0.174	0.777	0.346			
G	0.793	0.457	0.640	0.522	0.801	0.259		
H	0.171	0.368	0.104	0.194	0.171	0.322	0.231	

A-Affective component of the attitude toward AI, B-Behavioural Component of the attitude toward AI, C-Cognitive Component of the attitude toward AI, D-Discomfort component of Technology Readiness Index, E-Innovativeness component of Technology Readiness Index, F- Insecurity component of Technology Readiness Index, G-Optimism component of Technology Readiness Index and H-Willingness to integrate AI- chatbots in teaching-learning process.

Convergent validity

The Tables 6 and 7 below contains the various reliability and validity indexes of the measured constructs in the model. Cronbach Alpha values measures the internal consistency and by extension the extent to which items of a scale or constructed are correlated. The Cronbach Alpha's value closer to 1 indicate stronger internal consistency. The composite reliability (rho_a and rho_c) are also alternative means of calculating the internal consistency of the constructs.

Average variance extracted (AVE) measures the amount of variance captured by the construt in relation to the amount of variance due to measurement error. A higher AVE value equal or above 0.5 indicated significant validity index. The Table5 shows the reliability and validity indexes of the combined In and pre-service responses on the constructs in the model while Table6 shows the separate reliability and validity indexes of In and Pre-service teachers' responses since the study is on multi-group analysis.

Table 6. Complete table for both In and Pre-service physics teachers' responses on constructs in the model.

Complete				
Construct	Cronbach Alpha	Composite Reliability Rho_a	Composite Reliability Rho_c	Average Variance Extracted (AVE)
A	0.920	0.933	0.943	0.805
B	0.605	0.728	0.783	0.515
C	0.889	0.905	0.922	0.749
D	0.862	0.897	0.914	0.781
E	0.955	0.959	0.967	0.881
F	0.915	0.938	0.946	0.854
G	0.956	0.961	0.968	0.883
H	0.834	0.873	0.897	0.743

Table 7. Tables for both In and Pre-service physics teachers' responses on constructs in the model.

In-service				
Construct	Cronbach Alpha	Composite Reliability Rho_a	Composite Reliability Rho_c	Average Variance Extracted (AVE)
A	0.925	0.935	0.947	0.816
B	0.637	0.777	0.793	0.535
C	0.896	0.926	0.926	0.759
D	0.853	0.920	0.901	0.754
E	0.965	0.968	0.974	0.904
F	0.892	0.960	0.919	0.792
G	0.952	0.958	0.965	0.875
H	0.791	0.798	0.877	0.705
Pre-service				
Construct	Cronbach Alpha	Composite Reliability Rho_a	Composite Reliability Rho_c	Average Variance Extracted (AVE)
A	0.913	0.931	0.939	0.793
B	0.555	0.673	0.764	0.484
C	0.881	0.889	0.918	0.737
D	0.870	0.880	0.921	0.795
E	0.942	0.948	0.958	0.852
F	0.931	0.936	0.956	0.879
G	0.961	0.965	0.972	0.896
H	0.880	0.931	0.922	0.798

A-Affective component of the attitude toward AI, B-Behavioural Component of the attitude toward AI, C-Cognitive Component of the attitude toward AI, D-Discomfort component of Technology Readiness Index, E-Innovativeness component of Technology Readiness Index, F- Insecurity component of Technology Readiness Index, G-Optimism component of Technology Readiness Index and H-Willingness to integrate AI- chatbots in teaching-learning process.

Structural model

Testing of the Research Hypotheses

HO_1: Behavioural, Cognitive and Affective components of attitude towards AI significantly related to willingness to integrate AI physics enabled Chatbots into teaching-learning process;

The interpretation of the Table 8 above indicated that the relationship between the three components of attitude towards AI and willingness to integrate AI chatbots into teaching-learning process are low, moderate, positive (Affective & Behavioural) and negative (Cognitive) though all the components are significantly related.

HO_2. Behavioural, Cognitive and Affective component of attitude towards AI significantly related to optimism (motivator) component of technology readiness index;

Table 8. Complete (In-service and Pre-service) Coefficient Table of Attitude towards AI and Willingness to integrate AI chatbots in teaching-learning process.

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
AFF -> WILL	0.211	0.209	Positive/Low	2.438	0.015	Supported
BE -> WILL	0.367	0.364	Positive/Moderate	4.910	0.000	Supported
COG -> WILL	-0.348	-0.343	Negative/Moderate	4.139	0.000	Supported

AFF – Affective Component of the attitude toward AI,BE - Behavioural Component of the attitude toward AI,COG- Cognitive component of the attitude toward AI and WILL- Willingness to integrate AI chatbots in teaching-learning process.

The interpretation of the Table 9 above indicated that the relationship between the three components of attitude towards AI and optimism component of technology readiness index are low, substantial, positively

related though the relationship between behavioural and cognitive components attitude towards AI with optimism component of technology readiness index were not significant.

HO_3. Behavioural, Cognitive and Affective component of attitude towards AI significantly related to innovativeness (motivator) component of technology readiness index;

Table 9. Complete (In-service and Pre-service) Coefficient Table of Attitude towards AI and Optimism component of technology readiness index.

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
AFF -> OPT	0.717	0.715	Positive/Substantial	15.986	0.000	Supported
BE -> OPT	0.052	0.054	Positive/Low	1.298	0.194	Not Supported
COG -> OPT	0.057	0.057	Positive/Low	0.992	0.321	Not Supported

AFF – Affective Component of the attitude toward AI,BE - Behavioural Component of the attitude toward AI,COG- Cognitive component of the attitude toward AI and OPT- Optimism Component of Technology Readiness Index.

The interpretation of the Table 10 above indicated that the relationship between the three components of attitude towards AI and innovativeness component of technology readiness index are low, substantial, positively (Affective component) and negatively (Behavioural and Cognitive components) related though the relationship between behavioural and cognitive components attitude towards AI with innovativeness component of technology readiness index were not significant.

HO_4. Behavioural, Cognitive and Affective component of attitude towards AI significantly related to insecurity (inhibitor) component of technology readiness index;

Table 10. Complete (In-service and Pre-service) Coefficient Table of Attitude towards AI and Innovativeness component of technology readiness index.

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
AFF -> INN	0.622	0.621	Positive/Substantial	11.681	0.000	Supported
BE -> INN	-0.050	-0.048	Negative/Low	0.950	0.342	Not Supported
COG -> INN	-0.033	-0.034	Negative/Low	0.507	0.612	Not Supported

AFF – Affective Component of the attitude toward AI, BE - Behavioural Component of the attitude toward AI,COG- Cognitive component of the attitude toward AI and INN- Innovativeness Component of Technology Readiness Index.

The interpretation of the Table 11 above indicated that the relationship between the three components of attitude towards AI and insecurity component of technology readiness index are low, positively (Affective & Cognitive components) and negatively (Behavioural component) related though the relationship between the constructs were not significant.

HO_5. Behavioural, Cognitive and Affective component of attitude towards AI significantly related to discomfort (inhibitor) component of technology readiness index;

Table 11. Complete (In-service and Pre-service) Coefficient Table of Attitude towards AI and Insecurity component of technology readiness index.

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
AFF -> INS	0.075	0.076	Positive/Low	1.034	0.301	Not Supported
BE -> INS	-0.044	-0.042	Negative/Low	0.606	0.545	Not Supported
COG -> INS	0.054	0.053	Positive/Low	0.616	0.538	Not Supported

AFF – Affective Component of the attitude toward AI,BE - Behavioural Component of the attitude toward AI,COG- Cognitive component of the attitude toward AI and INS- Insecurity Component of Technology Readiness Index.

The interpretation of the Table 12 above indicated that the relationship between the three components of attitude towards AI and discomfort component of technology readiness index are low, moderate, positively (Affective component) and negatively (Behavioural and Cognitive components) related though the relationship between behavioural and cognitive components of attitude towards AI with innovativeness component of technology readiness index were not significant.

HO_6. Optimism, Innovativeness, Discomfort and Insecurity components of technology readiness index significantly related to willingness to integrate AI chatbots in teaching-learning process.

The interpretation of the Table 13 above indicated that the relationship between the four components of technology readiness index and willingness to integrate th AI chatbots into teaching-learning process are low, moderate, positively (Innovativeness & Insecurity component) and negatively (Optimism and Discomfort components) related though the relationship between optimism component of technology readiness index was not significantly related to willingness to integrate AI chatbots into teaching-learning process.

Table 12. Complete (In-service and Pre-service) Coefficient Table of Attitude towards AI and Discomfort component of technology readiness index.

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
AFF -> DIS	0.408	0.410	Positive/Moderate	6.215	0.000	Supported
BE -> DIS	-0.060	-0.059	Negative/Low	0.831	0.406	Not Supported
COG -> DIS	-0.042	-0.043	Negative /Low	0.501	0.617	Not Supported

AFF – Affective Component of the attitude toward AI,BE - Behavioural Component of the attitude toward AI,COG- Cognitive component of the attitude toward AI and DIS- Discomfort Component of Technology Readiness Index.

Table 13. Complete (In-service and Pre-service) Coefficient Table of components of technology readiness index and willingness to integrate AI chatbots into teaching-learning process.

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
OPT -> WILL	-0.027	0.027	Negative/Low	0.306	0.760	Not Supported
INN -> WILL	0.294	0.289	Positive/Low	2.980	0.003	Supported
INS -> WILL	0.457	0.460	Positive /Moderate	5.814	0.000	Supported
DIS -> WILL	-0.432	-0.431	Negative /Moderate	4.508	0.000	Supported

OPT- Optimism component of technology readiness index, INN- Innovativeness component of technology readiness index, INS- Insecurity component of technology readiness index, DIS- Discomfort component of technology readiness index and WILL- Willingness to integrate AI chatbots in teaching-learning process.

The interpretation of the Table 14 above shows the result of group A (In-service) and it indicated that the relationship between the three components of attitude towards AI and willingness to integrate AI chatbots into teaching-learning process are moderate, positive (Affective & Behavioural) and negative (Cognitive) though all the components are significantly related.

Table 14. In-service Coefficient Table of Attitude towards AI and Willingness to integrate AI chatbots in teaching-learning process.

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
AFF -> WILL	0.315	0.307	Positive/Moderate	2.181	0.029	Supported
BE -> WILL	0.362	0.349	Positive/Moderate	2.900	0.004	Supported
COG -> WILL	-0.359	-0.339	Negative/Moderate	5.814	0.000	Supported

AFF – Affective Component of the attitude toward AI,BE - Behavioural Component of the attitude toward AI,COG- Cognitive component of the attitude toward AI and WILL- Willingness to integrate AI chatbots in teaching-learning process.

The interpretation of the Table 15 above shows the result of group B (Pre-service) and it indicated that the relationship between the three components of attitude towards AI and willingness to integrate AI chatbots into teaching-learning process are low, moderate, positive (Affective & Behavioural) and negative (Cognitive) though affective component of the attitude towards AI relationship with willingness to integrate AI chatbots into teaching-learning process was not significant.

Table 15. Pre-service Coefficient Table of Attitude towards AI and Willingness to integrate AI chatbots in teaching-learning process.

Path	Path Coeff. (β)	Coeff. Mean	Remark	T-value	P-value	Remark
AFF -> WILL	0.088	0.079	Positive/Low	0.784	0.433	Not Supported
BE -> WILL	0.382	0.380	Positive/Moderate	3.897	0.000	Supported
COG -> WILL	-0.341	-0.329	Negative/Moderate	3.128	0.002	Supported

AFF – Affective Component of the attitude toward AI,BE - Behavioural Component of the attitude toward AI,COG- Cognitive component of the attitude toward AI and WILL- Willingness to integrate AI chatbots in teaching-learning process.

Research questions

RQ1. Does difference exist in relationship between in and pre-service physics teachers' attitude towards AI and willingness to integrate AI physics enabled chatbots in teaching-learning process?

Multi-group difference between In and Pre-service physics teacher's willingness to integrate AI chatbots in teaching-learning process.

The differences are not significantly supported by both In and Pre-service physics teachers

The interpretation of the Table 16 above shows the result of multi-group difference (In-service - Pre-service) and it indicated that the relationship between the three components of attitude towards AI and willingness to integrate AI chatbots into teaching-learning process. The In-service physics teachers' affective component of the attitude towards AI was higher than pre-service physics teachers though the other two components (Behavioural and Cognitive components) favours the Pre-service physics teachers and all the difference were not significant.

Table 16. In and Pre-service Path Coefficient of Attitude towards AI and Willingness to integrate AI chatbots in teaching-learning process difference.

Path Relationship	Difference (In-service – Pre-service)	P-value	Remark
AFF -> WILL	0.227	0.211	Not Supported
BE -> WILL	-0.020	0.929	Not Supported
COG -> WILL	-0.017	0.910	Not Supported

RQ2. Which of the attitude towards AI and Technology readiness index mostly predict the respondents' willingness to integrate AI physics enabled Chatbots in teaching-learning process?

The research question two was answered using machine model called Neural Network. The variable importance Table 17 and Figure 2 below explains that the respondents' attitude towards AI predicted and forecasted their willingness to integrate AI chatbots into teaching-learning process.

Table 17. Independent Variable Importance.

	Importance	Normalized Importance
Attitude towards AI	.778	100.0%
Technology Readiness Index	.222	28.5%

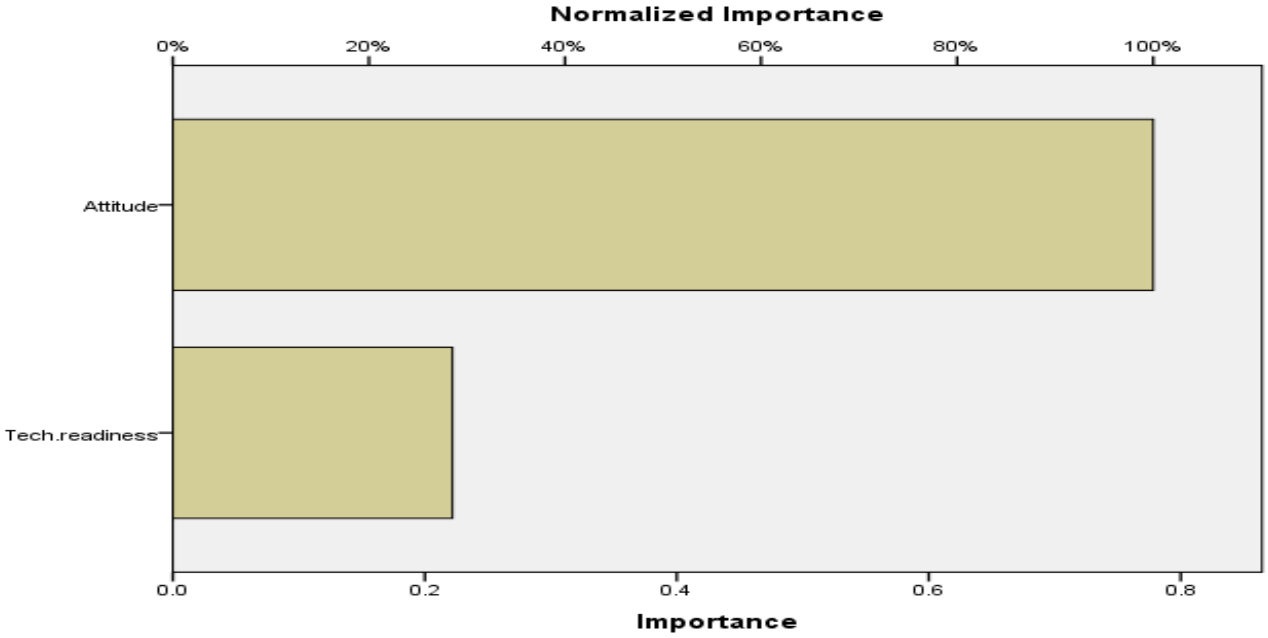

Figure 2. The Neural Network Graphical Output of the Importance of Independent Variables (Constructs).

The interpretation of the above Table 17 indicated that respondents' attitude towards AI remain the most important factor that can aid the teachers to integrate the AI chatbots in their teaching-learning process.

Discussion (Separate topics)

This study explored the attitude toward artificial intelligence, technology readiness index and their relationship between In and Pre-service physics teachers' willingness to integrate AI chatbots into teaching-learning process at secondary school physics class. The findings of this research show that the affective, behavioural and cognitive components of the attitude toward AI are significantly correlated with In and Pre-service physics teachers willingness to integrate AI chatbots in teaching-learning process. The first research hypothesis that was formulated and tested was to examine the correlation strength and significance of their correlation. The first hypothesis tested the relationship between attitude towards AI and In and Pre-service physics teachers' willingness to integrate AI chatbots into teaching-learning process. The result in Table 8 revealed that affective component of the attitude towards AI had low and positive correlation coefficient with willingness to integrate AI chatbots, behavioural component had moderate and positive correlation with

willingness to integrate AI chatbots while cognitive had moderate and negative correlation with willingness to integrate AI chatbots though all the three components of the attitude towards AI were all significantly correlated with willingness to integrate AI chatbots to teaching-learning process. The implication of this result means that the improvement in affective and behavioural components of the attitude towards AI will also improve the respondents' willingness to integrate AI chatbots into teaching-learning process. The cognitive component of the attitude towards AI' s relationship with respondents' willingness to integrate AI chatbots into teaching-learning process revealed that the improvement in cognitive component of the attitude towards AI reduces the respondents' willingness to integrate AI chatbots into teaching-learning process.

The second major formulated hypothesis which shows the linear relationship between technology readiness index's components and respondents' willingness to integrate AI chatbots into teaching-learning process. The results in Table8 revealed that optimism and discomfort components of technology readiness index had low, moderate, negative correlation with willingness to integrate AI chatbots into teaching-learning process though discomfort component significantly correlated with the willingness to integrate AI chatbots into teaching-learning process. The innovativeness and insecurity components of technology readiness index had low, moderate, positive correlation and significantly correlated with respondents' willingness to integrate AI chatbots into teaching-learning process. The result explained that optimism (motivator) and discomfort (inhibitor) of the technology readiness index might not influence the respondents' willingness to integrate AI chatbots teaching-learning process while the innovativeness (motivator) and insecurity (inhibitor) of the technology readiness index might influence the respondents' willingness to integrate AI chatbots into teaching-learning process.

The first research question raised was centred on the multi-group analysis difference of the In and pre-service physics teachers' attitude towards AI and their willingness to integrate AI chatbots into teaching-learning process. The results in Table15 revealed that In-service physics teachers' affective component of the attitude towards AI was higher than pre-service physics teachers though the other two components (Behavioural and Cognitive components) favours the Pre-service physics teachers and all the differences were not significant.

The second research question raised was on the exogenous (independent) variables' importance and their influence on the endogenous (willingness to integrate AI chatbots into teaching-learning process). The neural network result in Table16 explained that the respondents' attitude towards AI remain the most important factor that might influence the decision of the respondents' to willingly integrate and adopt the usage of AI chatbots in teaching-learning process.

Conclusion

The adoption and integration of the AI chatbots in classroom teaching-learning and communication process are fast growing and gaining momentum globally. The usage of AI chatbots by many professionals in enhancing their job output is on the rise and the educational sector is not left out. The result of the study concluded that attitude towards AI plays significant roles in adoption, integration, usage and recommendation of chatbots to solve human and machine related problems.

References

Adiguzel, T., Kaya, H., & Cansu, F. (2023). *Revolutionizing education with AI: exploring the transformative potential of ChatGPT.* Comtemporary Educational Technology, 15(3), 1-13. https://doi.org/10.30935/cedtech/1315

Barkirtas, H., & Akkas, C. (2020). *Technology readiness and technology acceptance of academic staffs.* International Journal of Management Economics and Business, 16(4), 1043-1058. https://doi.org/.10.17130/ijmeb.853629

Blut, M., & Wang, C. (2019). *Technology readiness: a meta-analysis of conceptualization of the construct and its impact on technology usage.* Journal of the Academy of Marketing Science, 48, 649-669. https://doi.org/10.1007/s11747-019-00680-8

Chatterjee, S., & Bhattacharjee, K. K. (2020). *Adoption of artificial intelligence in higher education: a quantitative analysis using structural equation modelling.* Education and Information Technologies, 25, 3443-3463. https://doi.org/10.1007/s10639-020-10159-7

Chiu, Y.-T., Zhu, Y.-Q., & Corbett, J. (2021). *In the hearts and minds of employees: a model of pre-adoptive appraisal toward artificial intelligence in organizations*. International Journal of Information Management, 60, 102379. https://doi.org/10.1016/J.IJINFOMGT.2021.102379

Conner, M., Wilding, S., Harreveld, F. van, & Dalege, J. (2020). *Cognitive-affective inconsistency and ambivalence impact on the overall attitude-behaviour relationship.* Personality & Social Psychology Bulletin, 47(4), 673-687. https://doi.org/10.1177/0146167220945900

Dimitriadis, G. (2020). *Evolution in education: Chatbots*. Homo Virtualis, 3(1),47-54. https://doi.org/10.12681/homvir.23456

Durak, H. Y., & Onan, A. (2023). *An examination of studies on the use of Chatbots technology in the field of education*. In 5th International Conference on Applied Engineering and Natural Sciences, 121-123. https://as-proceeding.com/

Fernoaga, V., Stelea, G.-A., Gavrila, C., & Sandu, F. (2018). *Intelligent education assistant powered by chatbots*. Proceedings of *14th International Conference E-learning and Software for Education*. Bucharest. https://doi.org/10.12753/2066-026x-18-122

Gonda, D. E., & Chu, B. (2019). *Chatbots as a learning resource? Creating conversational bots as a supplement for teaching assistant course*. Proceedings of International Conference on Engineering, Technology and Education (TALE), 1-5. https://doi.org/10.1109/TALE48000.2019.9225974

Jarrar, Y., Awobamise, A. O., & Sellos, P. S. (2020). *Technological readiness index (TRI) and the intention touse smartphone apps for tourism: a focus on inDubai mobile tourism app.* International Journal of Data and Network Science, 4, 297-304. https://doi.org/10.5267/j.ijdns.2020.6.003

Julian, R. K., & Dhini, A. (2022). *The role of technology readiness towards acceptance on smartwatch use*. In Proceedings of the 7th North American International Conference on Industrial Engineering and Operations Management. 1990-1999. https://doi.org/10.46254/na07.2022449

Lin, C., Huang, A. Y. Q., & Yang, S. J. H. (2023). *A review of AI-driven conversational chatbots implementation methodologies and challenges (1999-2022).* Sustainability, 15(5), 4012. https://doi.org/10.3390/su15054012

Liu, L., Subbareddy, R., & Raghavendra, C. G. (2022). *AI intelligence chatbot to improve students learning in the higher education platform.* Journal of Interconnection Networks, 22(2), 1-17. https://doi.org/10.1142/s021926592143

Mageira, K., Pittou, D., Papasalouros, A., Kotis, K., Zangogianni, P., & Daradoumis, A. (2022). *Educational AI Chatbots for content and language integrated learning*. Applied Science, 12(7), 3239. https://doi.org/10.3390/app12073239

Malik, R., Shrama, A., Trivedi, S., & Mishra, R. (2021). *Adoption of Chatbots for learning among university students: role of perceived convenience and enhanced performance.* International Journal of Emerging Technologies in Learning, 16(18), 200-212. https://doi.org/10.3991/ijet.v16i18.24315

P, M. G. C., Srivastava, A., Chakraborty, S., Ghosh, A., & Raj, H. (2021). *Development of information technology telecom chatbot: an artificial intelligence and machine learning approach*.In Proceedings of 2nd International Conference on Intelligent Engineering and Management [ICIEM] (pp. 216-221).https://doi.org/10.1109/ICIEM51511.2021

Parasuraman, A. (2000). *Technology readiness index(Tri): a multiple-item scale to measure readiness to embrace new technologies.* Journal of Service Research, 2(4), 307-320. https://doi.org/10.1177/109467050024001

Parasuraman, A., & Colby, C. L. (2015). *An updated and streamlined technology readiness index: TRI 2.0*. Journal of Service Research,18(1), 59-74. https://doi.org/10.1177/1094670514539730

Prananta, A. W., Susanto, N., Purwantoro, A., & Fuadah, N. (2023). *ChatGPT artificial intelligence integration in science learning media: systematic literature review*. Jurnal Penelitian Pendidikan IPA, 9(7), 315-321. https://doi.org/10.29303/jppipa.v9i7.4386

Riza, A. N. I., Hidayah, I., & Santosa, P. I. (2023). Use of chatbots in e-learning context: a systematic review.In Proceedings of IEEE World AI loT Congress (AlloT), Seattle, WA. https://doi.org/10.1109/AIIOT58121.2023.10174319

Sandu, N., & Gide, E. (2019). *Adoption of AI-Chatbots to enhance student learning experience in higher education in India.* In 18th International Conference on Information Technology Based Higher Education and Training (ITHET), Magdeburg, DE. https://doi.10.1109/ithet46829.2019.8937382

Schepman, A., & Rodway, P. (2020). *Initial validation of the general attitudes towards artificial intelligence scale.* Computers in Human Behavior Reports, 1, 100014. https://doi.org/10.1016/J.chbr.2020.100014

Suh, W., & Ahn, S. (2022). *Development and validation of a scale measuring student attitudes toward artificial intelligence*. SAGE Journal, 12(2). https://doi.org/10.1177/21582440221100463

Supriyadi, E., & Kuncoro, K. S. (2023). *Exploring the future of mathematics teaching: insight with ChatGPT*. Union Jurnal Ilmiah Pendidikan Matematika, 11(2), 305-316. https://doi.org/10.30738/union.v11i2.14898

West, C. G. (2023). AI and the FCI: *Can ChatGPT project an understanding of introductory physics?* ArXiv. https://doi.org/10.48550/arXiv.2303.01067

Wolf, L. J., Haddock, G., & Maio, G. R. (2020). *Attitudes*. *Oxford Research Encyclopedia of Psychology*.https://doi.org/10.1093/acrefore/9780190236557.013.247

INFORMATION ABOUT THE AUTHORS

Wasiu Olayinka Yahaya is a lecturer in the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Kwara State Nigeria. The author worked on instrument development, data collection, article' content development and data analysis.
ORCID: https://orcid.org/0000-0002-2130-2847
E-mail: yahaya.wo@unilorin.edu.ng

Abdulrasaq Oladimeji Akanbi is a Professor of Physics Education in the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Kwara State, Nigeria. The author worked on article's content and instrument development.
ORCID: https://orcid.org/0000-0001-7291-2090
E-mail: akanbi.ao@unilorin.edu.ng

Abdulkadir Aishat Yusuf is a lecturer in the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Kwara State, Nigeria. The author worked on article's content and instrument development.
ORCID: https://orcid.org/0000-0001-8569-6278
E-mail: yusuf.aa@unilorin.edu.ng

NOTE:
Wasiu Olayinka Yahaya worked on instrument development, data collection, article' content development and data analysis. Abdulrasaq Oladimeji Akanbi worked on article's content and instruments ' development. Abdulkadir Aishat Yusuf worked on article's content and instrument development.

Associate editor responsible:
Maria Terezinha Bellanda Galuch (UEM)
ORCID: https://orcid.org/0000-0001-5154-9819
E-mail: mtbgaluch@uem.br

Evaluation rounds:
R1: Three invitations; Three opinion received

Standardization reviewer:
Adriana Curti Cantadori de Camargo

Data availability:
The data used for the study can assessed if requested from the authors.