Integrating Intelligent Feedback Models in E-Learning Platforms for Women's Digital Empowerment, Innovation, and Inclusion in the Digital Economy

Victoria Anthony Uwah
Department of Computer Science
Akwa Ibom State University of Education, Afaha Nsit, Nigeria

Essien Eyo Essien
Department of Computer Science,
University of Calabar, Calabar, Nigeria

ABSTRACT
This study examined the role of intelligent feedback models in empowering next-generation women and promoting participation in the digital economy through innovation and inclusion. The study was anchored on the Social Cognitive Theory (SCT) which emphasizes the influence of feedback and environmental factors on learners' behavior and self-efficacy. A descriptive survey research design was adopted. The population comprised female learners on e-learning platforms, from which a sample of 420 respondents was selected using purposive sampling. Data were collected using *Intelligent Feedback and Women's Digital Empowerment Questionnaire (IFWDEQ)*, which yielded a Cronbach's Alpha reliability coefficient of 0.89. Data were analyzed using frequency and percentage, mean and standard deviation, Pearson Product Moment Correlation, and regression analysis. The findings revealed that intelligent feedback significantly enhanced learner engagement (M=4.12, SD = 0.74), digital competence (M=4.10, SD = 0.68), and innovation capability (M=3.98, SD = 0.72), and from the hypothesis testing, the findings revealed that intelligent feedback significantly enhanced learner engagement ($\beta = .62$, $p < .001$), digital competence ($\beta = .68$, $p < .001$), and innovation capability ($r = .59$, $p < .001$). Digital competence also significantly influenced digital economic participation ($\beta = .71$, $p < .001$). The study concluded that intelligent feedback models are effective mechanisms for promoting women's digital empowerment, innovation, and inclusion. It was recommended that e-learning providers should incorporate adaptive feedback mechanisms to promote inclusive and sustainable digital development.

Keywords
Intelligent feedback, e-learning platforms, digital competence, women's digital empowerment, innovation, inclusion, digital economy.

1. INTRODUCTION
The rapid evolution of artificial intelligence, machine learning, and digital technologies has transformed educational systems worldwide. E-learning platforms have emerged as critical tools for developing workforce competencies and supporting lifelong learning. Simultaneously, governments and international organizations are prioritizing women's inclusion in digital economies as a strategy for achieving sustainable development and economic growth. The rapid advancement of Information and Communication Technology (ICT) has led to significant growth in the adoption of electronic learning (e-learning) as an alternative to the limitations associated with traditional face-to-face instructional methods. This growth has been driven largely by the increasing use of digital technologies among learners and the flexibility that e-learning offers in terms of time, location, and accessibility. Consequently, various e-learning platforms, particularly Learning Management Systems (LMSs), have emerged to support the delivery and management of online education.

E-learning has become an essential tool for achieving educational objectives, owing to the continuous evolution of communication technologies and digital networks. It encompasses all forms of learning and teaching supported electronically and involves the use of the Internet, computer networks, or standalone systems to facilitate knowledge acquisition. Commonly referred to as online learning, web-based learning, virtual learning, or online education, e-learning enables learners and instructors to interact within digital environments regardless of geographical boundaries.

An e-learning platform, often implemented through a Learning Management System (LMS), provides a structured environment for the delivery, administration, management, automation, and analysis of learning activities. These systems support both classroom and out-of-classroom learning experiences through the integration of information and communication technologies [7]. E-learning therefore represents the computer- and network-enabled transfer of knowledge and skills through web-based instruction, computer-assisted learning, virtual educational opportunities, and digital collaboration. As technological innovations continue to evolve, e-learning remains a critical component of contemporary education and lifelong learning.

Despite progress in digital education, significant gender disparities persist in access to digital skills, technology adoption, and participation in innovation ecosystems. Existing e-learning systems often provide generic learning experiences that do not adequately address individual learner needs, particularly those of women who may face unique barriers such as limited prior ICT exposure, socio-cultural constraints, and reduced confidence in digital environments. Generic feedback mechanisms fail to accommodate diverse learning styles and skill levels, reducing engagement and effectiveness.

Intelligent feedback models have the potential to personalize learning and enhance learner engagement though their role in promoting women's digital empowerment and fostering innovation remains insufficiently explored. Although e-learning platforms have expanded educational access, many women continue to experience low completion rates, inadequate learner support, and limited development of innovation-related competencies. Current research has not clearly established how AI-driven feedback within e-learning platforms can translate improved digital skills into meaningful socio-economic outcomes such as entrepreneurship, employability, and active participation in the digital economy. This gap limits the ability of educators, policymakers, and technology developers to design inclusive digital learning systems that not only improve

knowledge acquisition but also promote gender equality and economic inclusion. Therefore, there is a need to investigate how intelligent feedback models integrated into e-learning platforms can enhance women's digital empowerment, innovation capacity, and inclusion in the digital economy, particularly within the Nigerian context. This study empirically investigates how integrating intelligent feedback mechanisms within e-learning platforms can influence women's digital competence, innovation capacity, and readiness to participate in the digital economy.

1.1 Objectives of the Study

The objectives include, to:

1. Examine the effect of intelligent feedback on learner engagement.
2. Determine the influence of intelligent feedback on digital competence.
3. Investigate the relationship between intelligent feedback and innovation capability.
4. Assess the effect of digital competence on digital economic participation.
5. Evaluate the mediating role of digital competence between intelligent feedback and digital economic participation.

1.2 Research Questions

The study seeks to answer the following questions:

1. What is the effect of intelligent feedback on learner engagement?
2. To what extent does intelligent feedback influence digital competence?
3. To what extent exists does innovation capability manifest among learners.
4. What is the effect of digital competence on digital economic participation?
5. What relationship exist between digital competence, intelligent feedback and digital economic participation?

1.3 Null Hypotheses

H1: Intelligent feedback significantly influences learner engagement.

H2: Intelligent feedback significantly influences digital competence.

H3: Intelligent feedback significantly influences innovation capability.

H4: Digital competence significantly influences digital economic participation.

H5: Digital competence mediates the relationship between intelligent feedback and digital economic participation.

2. RELATED LITERATURE

2.1 Intelligent Feedback in E-Learning Platforms

The rapid advancement of Artificial Intelligence (AI), Machine Learning (ML), and data analytics has transformed conventional Learning Management Systems (LMS) into Intelligent Learning Management Systems (ILMS) capable of delivering personalized, adaptive, and interactive learning experiences [15]. Intelligent feedback models embedded in e-learning platforms utilize analytical and predictive capabilities to monitor learner behavior, identify knowledge gaps, provide real-time feedback, recommend appropriate learning pathways, and support continuous improvement. Unlike traditional learning systems, intelligent feedback mechanisms promote learner engagement, self-regulation, and individualized instruction through data-driven insights and automation.

The integration of intelligent feedback models significantly enhances the effectiveness of e-learning environments by incorporating adaptive learning, intelligent tutoring systems, automated assessment, learning analytics, and virtual assistance. Such technologies enable learners to receive timely and personalized support, thereby improving learning outcomes, motivation, and retention. Furthermore, the inclusion of feedback systems extends the capabilities of conventional LMS/LCMS platforms and contributes to the development of intelligent and inclusive learning ecosystems.

Machine learning, a major branch of Artificial Intelligence, plays a crucial role in these intelligent feedback systems by analyzing learner data to recognize patterns, predict outcomes, and recommend interventions. Through supervised, unsupervised, and reinforcement learning approaches, machine learning algorithms facilitate personalized learning experiences and enable educational systems to adapt to the diverse needs of learners.

Within the context of women's empowerment and the digital economy, integrating intelligent feedback models into e-learning platforms offers innovative opportunities for enhancing digital skills, fostering leadership development, promoting inclusion, and preparing next-generation women for active participation in technology-driven economies. By providing equitable and personalized learning experiences, intelligent feedback systems can contribute significantly to building a digitally competent, innovative, and inclusive female workforce capable of driving sustainable economic growth.

2.2 Impact of Intelligent Feedback Models on Women's Digital Empowerment

The integration of Intelligent Feedback Models (IFMs) into e-learning platforms has emerged as a transformative approach to enhancing women's digital empowerment in the knowledge-driven economy. Powered by Artificial Intelligence (AI), Machine Learning (ML), and learning analytics, intelligent feedback systems provide personalized, timely, and adaptive feedback based on learners' performance and preferences [16]. Unlike traditional feedback mechanisms, these systems continuously analyze learner interactions and recommend appropriate learning pathways, thereby improving learning effectiveness and promoting access to digital opportunities [1], [14], [9].

One of the major contributions of intelligent feedback models is the enhancement of women's digital skills and competencies. Personalized feedback enables learners to identify their strengths and weaknesses, receive immediate corrective guidance, and progress at their own pace. This individualized support facilitates the acquisition of essential digital skills, including ICT literacy, digital communication, and problem-solving abilities, thereby preparing women for emerging opportunities in the digital economy. In addition, intelligent feedback promotes learner engagement, motivation, and self-efficacy. Consistent with Social Cognitive Theory, positive feedback enhances learners' confidence and persistence [2]. Hattie and Timperley (2007)

further emphasized that effective feedback is among the most influential factors in improving learning and achievement.

Intelligent feedback models also foster innovation and entrepreneurial capabilities by encouraging critical thinking, creativity, and self-regulated learning. Through adaptive learning environments, women are able to explore alternative solutions, refine ideas, and develop competencies necessary for leadership and participation in the Fourth Industrial Revolution (Schwab, 2017). Studies have shown that digital skills contribute significantly to innovation and employability among learners [8].

Furthermore, intelligent feedback systems promote inclusion and equity by accommodating diverse learning styles, competency levels, and socio-economic backgrounds. This personalized approach reduces educational disparities and enhances access to quality learning opportunities, particularly for women from underserved communities [14]. Similarly, the World Bank (2024) emphasized that digital inclusion is essential for women's economic empowerment and labor market participation. Consequently, intelligent feedback models provide a foundation for women's leadership development, employability, and sustainable participation in the digital economy.

2.3 AI-Driven Adaptive Learning and Women's Digital Empowerment

The integration of Artificial Intelligence (AI) into e-learning environments has significantly transformed the design and delivery of education. AI-driven adaptive learning systems use machine learning, learning analytics, and intelligent feedback mechanisms to provide personalized instruction, real-time support, and tailored learning pathways that address learners' diverse needs. These systems improve learning outcomes while also promoting digital inclusion and empowerment, particularly for women. In the digital economy, AI-enabled learning environments support digital literacy, innovation, and equitable participation in technology-driven societies.

A major feature of AI-enabled learning is intelligent feedback systems, which deliver timely, personalized, and continuous feedback based on learner performance and interaction data. Unlike traditional instructor-based feedback, these systems automatically detect strengths and weaknesses, identify knowledge gaps, and recommend appropriate learning resources. As noted by Holmes et al. (2022), such systems enhance learning efficiency by providing adaptive guidance. Hattie and Timperley (2007) also emphasize that effective feedback helps learners understand their current progress, learning goals, and improvement strategies. Through predictive analytics and intelligent tutoring, AI feedback systems increase engagement, motivation, and self-regulation [12]. For women learners, they reduce dependence on immediate instructor availability and help overcome barriers related to limited mentorship.

Closely related are adaptive learning environments that dynamically adjust content, learning pace, and instructional strategies based on learner profiles. These systems recognize differences in background, ability, and learning style, offering personalized learning experiences that improve satisfaction and efficiency [3]. By enabling flexible and self-paced learning, they are especially beneficial for women balancing education with family or work responsibilities. [4] highlights that such flexible approaches expand access to education and support lifelong learning, particularly for marginalized groups.

The effectiveness of these systems is closely linked to digital literacy, which involves the ability to access, evaluate, and create information using digital technologies [14]. Digital literacy is essential for employability, entrepreneurship, and participation in the modern economy. However, gender disparities in access to digital tools and opportunities persist globally (World Bank, 2024). Enhancing women's digital literacy strengthens their technical skills, critical thinking, and problem-solving abilities, thereby improving economic participation. UN Women (2023) further notes that digital empowerment enhances women's entrepreneurship, independence, and social inclusion.

Technology acceptance is also critical to the success of AI-driven learning systems. The Technology Acceptance Model (Davis, 1989) explains that perceived usefulness and ease of use influence adoption, while the Unified Theory of Acceptance and Use of Technology. When learners perceive AI platforms as useful and easy to use, adoption increases. Intelligent feedback and adaptive systems strengthen these perceptions by reducing complexity and improving learning outcomes.

Overall, AI-driven adaptive learning promotes women's digital empowerment through personalized learning, intelligent feedback, digital literacy development, and increased technology acceptance. It enhances inclusion, reduces gender disparities, and equips women with the skills needed to participate effectively in the digital economy.

3. METHODOLOGY

3.1 Model Design

3.1.1 Users adaptive framework

The architecture illustrated in Fig.1 explains a conceptual framework of intelligent feedback mechanisms embedded in e-learning platforms that facilitate women's digital empowerment, innovation, and inclusion. The framework begins with the learner, who interacts with an e-learning platform that incorporates intelligent feedback technologies and learning analytics to provide personalized learning experiences. Through continuous analysis of learner characteristics, performance, and preferences, the system generates adaptive interventions that enhance learning outcomes and prepare women for active participation in the digital economy.

At the top of the framework is the **learner (e.g next-generation women)**, representing women who engage with e-learning platforms to acquire digital knowledge and skills. These learners possess varying learning styles, competencies, backgrounds, and cognitive abilities, all of which influence their interaction with digital learning environments.

Learners' Preference (LP) is a weighted interaction outcome of learning satisfaction, system characteristics, and personal preference structures within an AI-enabled e-learning environment. It is not just what learners experience, but how strongly each factor matters to them, especially under intelligent feedback conditions.

Mathematically,

$$LP=\sum(LS(x_1, x_2, x_3, \ldots, x_n),SC(i),PP((l,k),PARS))$$

Where:

- LP = Learners' Preference
- LS = Learning Satisfaction function
- SC = System Characteristics (or Social/Support Context)
- PP = Personal Preferences function
- x_n, i, l, k = input variables
- PARS = parameter set controlling preference sensitivity

The Index scale used for final computed LP and system comparison across users ranges from 0≤LP≤1.

2. Mathematical definition of variables

(a) Learning satisfaction (LS)

$LS(x_1, x_2,...,x_n) = w_1x_1+w_1x_2+\ldots+w_jx_j$

$$= \sum_{j=1}^{n} w_j\ x_j$$

Where:

- x_j = perceived content quality, feedback quality from system, ease of use of platform,, engagement level, other satisfaction indicators
- w_j = weight of each factor

(b) System Characteristics (SC)

$SC(i) = \alpha_1s_1+\alpha_1s_2+\ldots+\alpha_ms_m$

$$= \sum_{i=1}^{m} \alpha_i\ s_i$$

Where:

- s_i = accessibility of platform, AI adaptability level, responsiveness of feedback system, infrastructural quality
- α_i = importance weight of system feature

(c) Personal preference (PP)

$PP((l,k), PARS) = \beta_{11}P_{11}+\beta_{22}P_{22}+\ldots+\beta_{lk}P_{lk}$

$$= \sum_{k=1}^{q} \quad \sum_{k=1}^{q} \beta_{lk}\ P_{lk}$$

Where:

- P_{lk} = preference attribute (e.g., learning style, motivation, digital confidence level, gender- related learning sensitivity)
- β_{lk} = parameter sensitivity coefficient from PARS

3. Units of measurement: The unit of measurement used to measure variables for learning satisfaction (x_j), system characteristics (s_i) and personal preference (p_{lk}) is the Likert Scale

where ;

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

4. Explanation of weights

(a) w_j which stands for **Satisfaction Weights r**epresent the **importance of each learning satisfaction factor, e.g.** feedback quality may matter more than interface design.

The constraint.

$\sum \mathbf{w_j = 1}$

(b) α_i which stands for **System Weights r**epresent contribution of system features to learning experience, for example AI adaptability may be weighted higher than UI design for intelligent systems

The Constraint:

$\sum \alpha_i = 1$

(c) β_{lk} which stands for **Personal Preference Sensitivity Weights c**aptures **how strongly a learner responds to a factor.** These weights reflect gender differences in learning response, motivation level, digital confidence, and prior ICT exposure . Higher β means stronger influence on learner preference while Lower β means weaker influence.

Second framework : This is given as

$$LP \rightarrow PLCP \rightarrow UFS$$

The framework explains that learners' preference in e-learning is determined by the interaction of learning satisfaction, system characteristics, and personal factors, all mediated by an AI-driven feedback system, while being influenced by contextual variables such as gender digital divide and infrastructure availability.

In summary, the combination of Learning Satisfaction, LS (x1–xn) ---- wj ----) and System Characteristics, SC (s1–sm) ---- αi -------) and Personal Preference, PP (p1–pk) ---- βlk ----) process through an AI-Driven Intelligent Feedback System produces the final outcome called **Learners' Preference (LP)**

The framework therefore proposes that the integration of intelligent feedback models in e-learning platforms positively influences women's digital empowerment by providing personalized learning experiences that promote innovation, inclusion, and active participation in the digital economy. Thus, intelligent feedback acts as the mediating mechanism through which e-learning contributes to the development of next-generation women capable of driving sustainable digital transformation.

The ultimate outcome of the framework is women's digital empowerment. Through continuous feedback and adaptive learning, women develop digital competencies, technological confidence, and self-regulated learning skills that enable effective use of digital technologies and meaningful participation in the knowledge economy. According to [14] and the World Bank (2024), digital empowerment enhances innovation and inclusion by strengthening creativity, critical thinking, problem-solving, and entrepreneurial abilities, thereby improving women's participation in the digital economy and sustainable development. Personalized learning environments also promote equitable access to education regardless of socio-economic background, reducing digital inequalities (Holmes et al., 2022; [10], 2021). Overall, digital empowerment drives inclusion, innovation, and economic participation (UN Women, 2023).

3.2 Research Design

A quantitative cross-sectional survey design was adopted. The population consisted of female learners in online education programs, digital skill academies, and university e-learning platforms. Using Cochran's formula, a sample of 420 respondents was selected through purposive sampling to ensure representation across institutions. Data were collected using the Intelligent Feedback and Women's Digital Empowerment Questionnaire (IFWDEQ) with a total of 20 items, with five sections measuring learner engagement (item 1-5), digital competence(items 6-10), innovation capability(item 11-15), and digital economic participation (items 16–20). This questionnaire was generated in a google form and sent to female students studying in University of Uyo (200), Akwa Ibom State University (100), Akwa Ibom State University of Education (60) and Akwa Ibom State Polytechnic(60), responses were received within one month. All the items were measured using a five-point Likert scale with points distributed as Strongly Agree (5), Agree

(4), Undecided (3), Disagree (2) and Strongly Disagree (1). The instrument's reliability was 0.89 (Cronbach's alpha) and validated by 3 experts from the field of Educational Technology and 2 from Test and Measurement who studied the questions and made necessary adjustment. Ethical principles were strictly observed throughout the conduct of this study. Respondents were assured that the information provided would be treated with utmost confidentiality and used solely for academic

3.2.1 Instrument and Scoring Procedure

Section A: Demographic information

1. Age: 16–20 years [ ] 21–25 years [ ] 26–30 years [ ] 31 years and above [ ]
2. Educational Level: Undergraduate [ ] Postgraduate [ ]
3. Location: Urban [ ] Rural [ ]
4. Years of Experience with E-learning: Less than 1 year [ ] 1–3 years [ ] 4–6 years [ ] Above 6 years [ ]

Table 1: Questionnaire on intelligent feedback and learner engagement (IF-LE)

S/N	ITEMS	SA	A	UD	D	SD
1	The E-learning platform provides timely feedback on my learning activities					
2	Feedback from the system helps me correct my mistakes quickly					
3	The platform provides personalized recommendations based on my performance					
4	Intelligent feedback improves my understanding of course materials					
5	The feedback system adapts to my learning needs					

Table 2: Questionnaire on intelligent feedback and digital competence (IF-DC)

S/N	ITEMS	SA	A	UD	D	SD
6	I can effectively use e-learning platforms					
7	I can solve ICT-related problems					
8	I can use digital tools for learning activities					
9	I am confident in using online learning technologies					
10	I can search and evaluate information online effectively					

Table 3: Questionnaire on intelligent feedback and innovation capability

S/N	ITEMS	SA	A	UD	D	SD
11	I can generate new ideas using digital technologies					
12	I can solve problems creatively using ICT tools					
13	I use technology to develop innovative learning strategies					
14	I can apply digital tools in new ways					
15	I enjoy experimenting with digital learning technologies					

Table 4: Questionnaire on digital competence and digital economic participation

S/N	ITEMS	SA	A	UD	D	SD
16	I can use digtal skills for oncome generation					
17	I am interested in online business opportunities					
18	I can engage in freelancing or remote work					
19	I understand how to participate in the digital economy					
20	I intend to pursue digital entreprenuership					

Table 5: Variable scores

Sections	Questionnaire Items	Number of Items	Score Range
1	Learning Engagement (LE)	5	5-25
2	Digital Competence (DC)	5	5-25
3	Innovation Capability (IC)	5	5-25
4	Digital Economic Participation (DEP)	5	5-25
	Total Scale	**25**	**25-125**

Table 6: Decision rule for research questions

The criterion mean is calculated as:

Mean Range	Interpretation
4.50-5.00	Strongly Agree
3.50-4.49	Agree
2.50-3.49	Undecided
1.50-2.49	Disagree
1.00-1.49	**Strongly Disagree**

Responses with a mean score of 3.00 and above indicate agreement with the statement, while responses with a mean score below 3.00 indicate disagreement.

4. DATA PRESENTATION AND ANALYSIS

The statistical tool used in the analysis include Frequency & Percentage, Mean & Standard Deviation, and Pearson Moment Correlation.

4.1 Demographic Data (n = 420)

Table 7: Demoraphic data of a total of 420 respondents

Variable	Category	Frequency	Percentage(%)
Age	16-20	110	26.2
	21-25	180	42.9
18	26-30	90	21.4
	31+	40	9.5
Education	Undergraduate	280	66.7
	Postgraduate	140	33.3
Location	Urban	260	61.9
	Rural	160	38.1

4.2 Answering Research Questions

Research Question 1: What is the effect of intelligent feedback on learner engagement?

Table 8: Mean and standard deviation of effect of intelligent feedback on learner engagement

S/N	Item	Mean	SD	Decision
1	The E-learning platform provides timely feedback on my learning activities	4.18	0.72	Agree
2	Feedback from the system helps me correct my mistakes quickly	4.10	0.76	Agree
3	The platform provides personalized recommendations based on my performance	4.05	0.80	Agree
4	Intelligent feedback improves my understanding of course materials	4.21	0.68	Agree
5	The feedback system adapts to my learning needs	4.08	0.74	Agree
	Grand Mean	**4.12**	**0.74**	**Agree**

The grand mean of **4.12** indicates that respondents generally agreed that intelligent feedback systems enhance learner engagement by providing timely, adaptive, and personalized support. Item 4 recorded the highest mean (M = 4.21), suggesting that respondents particularly valued the contribution of intelligent feedback to understanding course materials.

However, the relatively higher standard deviations for Items 2 (SD = 0.76) and 3 (SD = 0.80) suggest some variation in respondents' opinions. This implies that although most learners perceived intelligent feedback positively, a number of respondents were less convinced about the system's ability to provide personalized recommendations and facilitate rapid error correction. Therefore, while intelligent feedback generally promotes learner engagement, its effectiveness may differ across users.

Research Question 2: To what extent does intelligent feedback affect digital competence?

Table 9: Mean and standard deviation of effect of intelligent feedback on digital competence

S/N	Item	Mean	SD	Decision
6	I can effectively use e-learning platforms	4.15	0.67	Agree
7	I can solve ICT-related problems	4.03	0.72	Agree
8	I can use digital tools for learning activities	4.18	0.64	Agree
9	I am confident in using online learning technologies	4.09	0.71	Agree
10	I can search and evaluate information online effectively	4.06	0.68	Agree
	Grand Mean	**4.10**	**0.68**	**Agree**

The grand mean of **4.10** shows that respondents generally

perceived intelligent feedback and e-learning experiences as contributing positively to their digital competence. The highest mean score was obtained for the ability to use digital tools for learning activities (M = 4.18), indicating strong confidence in this area.

Nevertheless, comparatively lower means for solving ICT-related problems (M = 4.03) and evaluating information online (M = 4.06) suggest that some respondents were uncertain about their problem-solving abilities. This indicates that improvements in digital competence are evident, although not all learners have attained the same level of proficiency.

Research Question 3: What effect of intelligent feedback and innovation capability?

Table 10: Mean and standard deviation of effect of intelligent feedback on innovation capability

S/N	Item	Mean	SD	Decision
11	I can generate new ideas using digital technologies	4.02	075	Agree
12	I can solve problems creatively using ICT tools	3.96	0.73	Agree
13	I use technology to develop innovative learning strategies	3.91	0.71	Agree
14	I can apply digital tools in new ways	4.01	0.69	Agree
15	I enjoy experimenting with digital learning technologies	4.00	0.74	Agree
	Grand Mean	**3.98**	**0.72**	**Agree**

The grand mean of **3.98** indicates moderate agreement that intelligent feedback contributes to innovation capability. Respondents generally agreed that intelligent feedback encourages creativity and experimentation with digital technologies.

However, Item 13 recorded the lowest mean (M = 3.91), indicating that some learners were less certain about using technology to develop innovative learning strategies. Likewise, the moderate standard deviations imply differences in respondents' experiences. These findings suggest that while intelligent feedback may foster innovation, its influence on creativity and strategic application of technology is not uniformly experienced among all learners.

Research Question 4

What is the effect of digital competence on digital economic participation?

Table 11: Mean and standard deviation of effect of digital competence on digital economic participation

S/N	Item	Mean	SD	Decision
16	I can use digtal skills for oncome generation	3.90	0.82	Agree
17	I am interested in online business opportunities	4.00	0.76	Agree
18	I can engage in freelancing or remote work	3.88	0.79	Agree
19	I understand how to participate in the digital economy	4.02	0.71	Agree
20	I intend to pursue digital entreprenuership	3.95	0.74	Agree
	Grand Mean	**3.95**	**0.76**	**Agree**

The grand mean of **3.95** suggests that respondents generally agreed that digital competence supports participation in the digital economy. Learners expressed interest in online business opportunities and demonstrated awareness of digital economic activities.

Nonetheless, lower mean scores for the ability to engage in freelancing or remote work (M = 3.88) and using digital skills for income generation (M = 3.90) indicate that some respondents were uncertain about translating their digital skills into actual economic benefits. The relatively high standard deviations further imply differing perceptions among participants. Therefore, although digital competence appears to facilitate economic participation, practical application of these skills remains challenging for some learners.

Research Question 5: What relationship exist between digital competence, intelligent feedback and digital economic participation?

Table 12:Correlation matrix showing the relationship between digital competence, intelligent feedback and digital economic participation

Variables	r	Sig.
Intelligent Feedback and Digital Competence	0.68	0.000
Intelligent Feedback and Digital Economic Participation	0.59	0.000
Digital Competence and Digital Economic Participation	0.71	0.000

Variables	**r**	**Sig.**
Intelligent Feedback and Digital Competence	0.68	0.000
Intelligent Feedback and Digital Economic Participation	0.59	0.000
Digital Competence and Digital Economic Participation (DEP)	0.71	0.000

The correlation results reveal significant positive relationships among intelligent feedback, digital competence, and digital economic participation. The strongest relationship was found between digital competence and digital economic participation (r = 0.71), suggesting that digital competence plays an important role in enabling learners to participate in economic activities.

However, the relationship between intelligent feedback and digital economic participation (r = 0.59) is comparatively weaker, indicating that intelligent feedback alone may not directly translate into economic participation. This suggests the presence of other factors, such as access to resources, socio-economic conditions, and digital opportunities, which may influence learners' ability to participate effectively in the digital economy.

4.3 Discussion of Findings

The findings of the study revealed that intelligent feedback significantly enhanced learner engagement among female learners on e-learning platforms. This finding supports the assertion of [5] that effective feedback promotes learners' motivation, participation, and academic improvement. Similarly, the result agrees with [6], who reported that AI-driven feedback systems improve learners' engagement and learning experiences.

The study also found that intelligent feedback significantly influenced digital competence, indicating that personalized learning environments contribute to the acquisition of digital skills. This finding is consistent with [14], which emphasized that technology-enhanced learning promotes digital literacy and lifelong learning. Furthermore, the positive relationship between intelligent feedback and innovation capability corroborates the findings of [10] and [3], who noted that adaptive learning environments foster creativity and problem-solving skills.

The study further established that digital competence significantly influenced digital economic participation. This finding supports the reports of [13] and the World Bank (2024), which highlighted digital skills as essential drivers of women's

economic empowerment, inclusion, and participation in the digital economy.

5. RECOMMENDATIONS

Institutions should adopt AI feedback, gender-responsive policies, and innovation learning; governments and industry should support women's digital empowerment initiatives.

6. CONCLUSION

This study provides evidence that Intelligent Feedback Models significantly enhance learner engagement, digital competence, innovation capability, and digital economic participation among women. The findings suggest that AI-driven feedback systems can become strategic tools for reducing gender disparities in digital education and promoting inclusive economic growth. Integrating intelligent feedback into e-learning platforms can empower next-generation women to become innovators, entrepreneurs, and leaders in the digital economy.

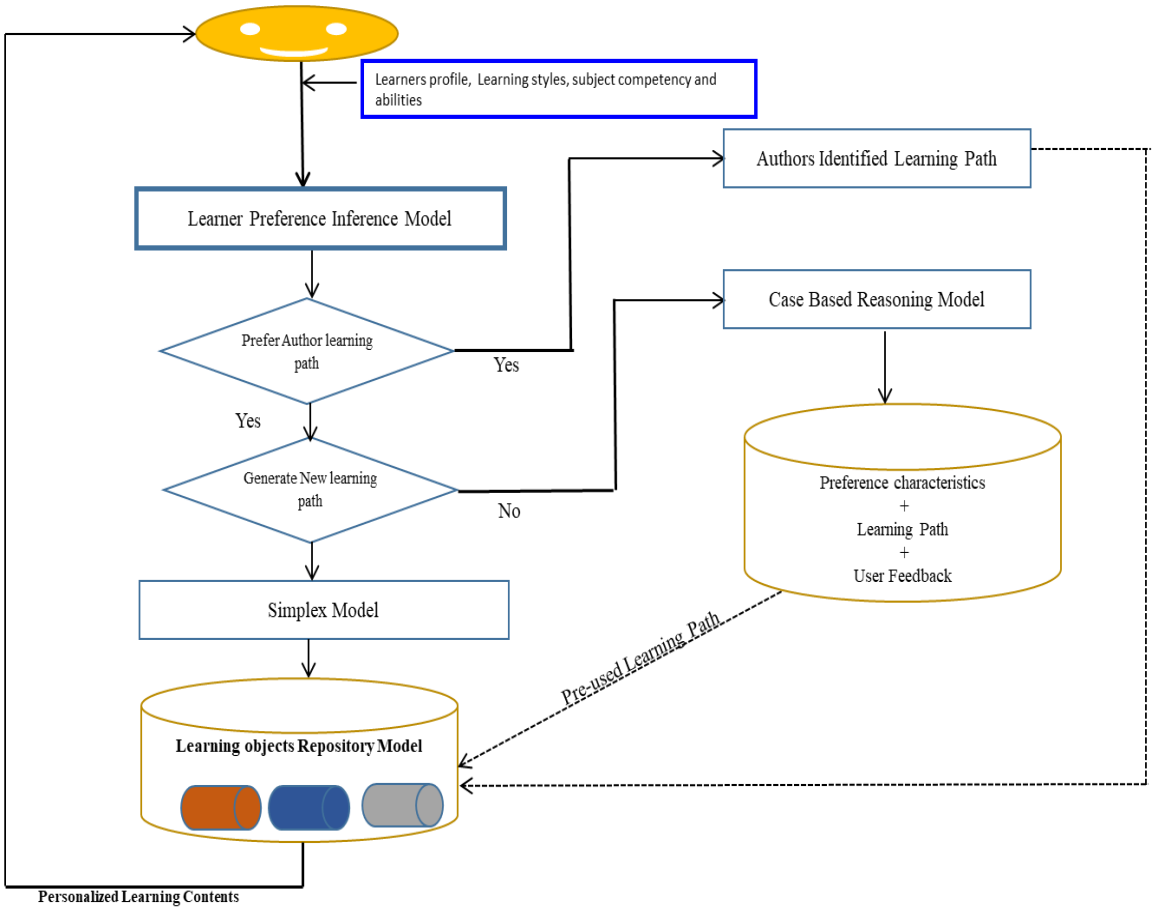

Fig 1: Users Adaptive Framework

7. REFERENCES

[1] Azevedo, R., & Bernard, R. M. (2023). Adaptive learning technologies and personalized education: Emerging trends and future directions. *Educational Technology Research and Development, 71*(4), 1257–1275.

[2] Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

[3] Durlach, P. J., & Lesgold, A. M. (2012). *Adaptive technologies for training and education*. Cambridge University Press.

[4] Gan, T. Y., Beevi, Z., Low, J., Lee, P. J., & Hall, D. A. (2022). Developing future-ready university graduates: Nurturing wellbeing and life skills as well as academic talent. *Frontiers in Psychology, 13*, 827517. https://doi.org/10.3389/fpsyg.2022.827517

[5] Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81–112. https://doi.org/10.3102/003465430298487

[6] Holmes, W., Persson, J., Chounta, I. A., Wasson, B., & Dimitrova, V. (2022). *Artificial intelligence and education: A critical view through the learning sciences*. International Journal of Artificial Intelligence in Education, 32(2), 303–344. https://doi.org/10.1007/s40593-021-00287-9

[7] Ihama, E. I. & Eguasa, O (2021). A review of virtual learning systems. *Benson Idahosa University Journal of Basic and Applied Sciences* 6(1): 29 – 41, Retrieved January 5th, 2023 from https://www.biu.edu.ng

[8] Lestari, Y. K., Agung, A. I., Buditjahjanto, I. G. P. A., Anifah, L., Wrahatnolo, T., Isnur, S., & Wanarti, P. (2024). Tackling the future: optimizing TVET students' employability skills through self-regulated learning and self-efficacy. *Ekuitas: Jurnal Pendidikan Ekonomi, 12*(1), 1–12.

[9] Lin, B. (2024). *Reinforcement Learning and Bandits for Speech and Language Processing*: Retrieved 18th July, 2024 from https://doi.org/10.1016/j.eswa.2023.122254

[10] Organisation for Economic Co-operation and Development

(OECD). (2021). *21st-century readers: Developing literacy skills in a digital world*. OECD Publishing. https://doi.org/10.1787/a83d84cb-en

[11] Pham, L. T. T. (2024). Work readiness of graduates in the digital age: A literature review. *Ho Chi Minh City Open University Journal of Science – Social Sciences, 14*(2), 1–18.

[12] Samina, A et al (2025). *Smart E-learning Framework for Personalized Adaptive Learning and Sequential Path Recommendations Using Reinforcement Learning*. Available in https://www.researchgate.net/publication/373153465

[13] UN Women. (2023). *Progress on the Sustainable Development Goals: The gender snapshot 2023*. UN Women and the United Nations Department of Economic and Social Affairs.

[14] UNESCO. (2023). *Global education monitoring report 2023: Technology in education—A tool on whose terms?* UNESCO Publishing.

[15] Uwah, V. A. & Ododo E. P. (2021). Transformation of instructional process: A review of artificial intelligence in higher institutions. An I*nternational Journal of* International Association for the Promotion of Asia-Africa Research Vol.1, 2021 ISSN: 2814-0400. 65-77.

[16] Uwah, V. A. & Ododo E. P. (2022). Effects of e-learning tools on students' academic performance in data structure. An I*nternational Journal of* International Association for the Promotion of Asia-Africa Research Vol. 2, 2022, ISSN: 2814-1409www.journals.iapaar.com.

[17] World Bank. (2024). *Women, business and the law 2024*. World Bank Publications. https://doi.org/10.1596/978-1-4648-2067-7