

An Analytical Examination of Andragogical Principles in the Implementation of Adaptive Technology for Adult Education

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Article info:

Submitted: July 9, 2024. Revised: September 7, 2024. Accepted: November 10, 2024.

Publish: November 17, 2024.

Abstract

The use of technology in education tailors' content and teaching methods to meet individual learning needs; however, significant challenges remain in its practical application. This study analyzes the implementation of adaptive technology in adult education and applies andragogical concepts in personalized, interactive, and problem-based learning. The research employed a quantitative survey with 249 respondents from various educational institutions and used Partial Least Squares Structural Equation Modeling (PLS-SEM) to evaluate the relationship between adaptive technology and andragogical learning strategies. The results indicate that adaptive technology has a positive and significant impact on andragogical learning strategies. Indicators such as technology accessibility, personalized learning, interactivity, and system integration support problem-based learning, self-directed learning, continuous feedback and evaluation, and contextual learning. The high outer loadings values demonstrate the significant contribution of each indicator to their constructs, and an R Square value of 0.369 indicates that 36.9% of the variability in andragogical learning strategies can be explained by adaptive technology. Adaptive technology can improve the quality of adult education by providing a more personalized, independent and interactive learning experience. So adequate infrastructure and educator training are needed to realize the full potential of adaptive technology.

Keywords: andragogical, education, adaptive, technology, personalized, learning

Recommended citation:

Darmawan, Sasmita, Dewi. (2024). An analytical examination of andragogical principles in the implementation of adaptive technology for adult education. *Edukasi*, 18(2), 95–105. <https://doi.org/10.15294/edukasi.v18i2.9190>

INTRODUCTION

The use of technology in education can tailor content and teaching methods based on the individual needs of learners (McKnight et al., 2016). Adaptive technology in personalized learning can cater to individual needs, learning styles, and paces, thereby enhancing motivation and learning efficiency (Shemshack et al., 2021). Adaptive technology applied in adult education can increase engagement and participation through interactive elements, enable better accessibility with flexible learning times and locations, and ensure equitable access for all learners, including those with special needs (Fadieieva, 2023). The results are improved learning outcomes and better retention of information, the development of essential digital skills, and more optimal use of teachers' time and resources, making the overall teaching and learning process more effective, efficient, and satisfying.

Implementing adaptive technology in adult education, which follows the principles of andragogy, can bring significant benefits since andragogy emphasizes relevant, practical, and learner-centered education (Abeni, 2020; Fadieieva, 2023; Farmer, 2010). Adaptive technology can identify individual needs and learning styles and then adjust the teaching materials and methods accordingly, thus enhancing the relevance and effectiveness of the learning process (Copriady, 2014; McKnight et al., 2016). Adult learners benefit from personalized learning, allowing them to learn at their own pace and according to their preferences while receiving real-time feedback that helps them understand and correct mistakes immediately.

Additionally, adaptive technology facilitates flexibility in learning times and locations, which is crucial for adult learners who often have busy schedules (Cleary et al., 2022; Tekkol & Demirel, 2018). Learner interaction and engagement can also be increased through interactive elements like quizzes, simulations, and educational games commonly included in adaptive platforms (Lemmetty & Collin, 2020). This not only makes the learning process more engaging but also helps reinforce understanding and retention of information (Palmer et al., 2011). Furthermore, this technology can provide equal access to all learners, including those with special needs, by tailoring content to be accessible to everyone (Nepo, 2017). Therefore, implementing adaptive technology in andragogical education can create a more inclusive, effective, and satisfying learning environment for adult learners.

Knowles (1984) emphasizes that adults bring unique experiences, knowledge, and needs to the learning process (Calder & Foletta, 2018; Knowles, 1984). Andragogy and technology have emerged as tools to create more adaptive and individualized learning experiences (Alhramelah et al., 2014; Nepo, 2017). According to (Wozniak, 2020), one of the main principles of andragogy is that adults are motivated to learn when they find the learning relevant to their lives. Technology, with its various platforms and tools, allows for the customization of learning materials to be more relevant and contextual. For instance, Learning Management Systems (LMS) enable instructors to design curricula tailored to individual needs and preference (Galustyan et al., 2019). LMS can offer flexible learning modules, allowing learners to study at their own pace and according to their schedules (Furqon et al., 2023).

Moreover, technology can help create a more interactive and collaborative learning environment (Kumar Basak et al., 2018). Applications such as online discussion forums, webinars, and virtual classrooms provide platforms for adult learners to share experiences, exchange ideas, and learn from each other (Qureshi et al., 2022). This collaboration not only enriches the learning experience but also reinforces the concept that learning is a dynamic social process (Azorín, 2022). Adaptive technology, which uses algorithms to tailor learning materials based on individual progress and preferences, offers significant potential in adult education (Wandelt et al., 2020).

However, the implementation of technology in adaptive learning is not without challenges. One major challenge is the digital divide (Lythreath et al., 2022). While technology can enhance accessibility, not all learners have equal access to devices and stable internet connections (Rahiem, 2020). Therefore, it is essential for educational institutions to consider inclusive solutions to bridge this gap, such as providing hardware or internet access to those in need (Sarri et al., 2010). Additionally, there are challenges regarding the readiness of instructors and learners to use technology effectively. Continuous training and support are necessary to ensure that all parties can fully utilize the technology. Instructors need to be trained to integrate technology into their teaching methods, while learners need guidance in using technological tools to support their learning.

Overall, the combination of andragogical concepts and adaptive technology offers great opportunities to enhance the quality of adult education. With a learner-centered approach and the appropriate use of technology, adult educators can create more relevant, interactive, and individualized learning experiences. However, to realize the full potential of technology in adult education, there must be a commitment to addressing existing challenges and ensuring that all learners have equal access to resources and learning opportunities.

Pandita & Kiran (2023) emphasize that while technology can support learning, there is a concern that learners might "end up alone with the computer" when using technology. This contradicts their earlier statement that adult learning should take place in social and physical environments. Their concern is also confirmed by i & Yang (2016), who explain that technology has become an integral part of daily life and work. Information and knowledge are now managed and shared using ubiquitous technology, modern information and communication technologies that allow access to information 'anytime, anywhere'. Learning environments utilizing ubiquitous technology support the learning processes required to keep up with new developments (Pimmer et al., 2016). In this context, work and learning become interrelated, existing within social and physical work situations.

Assuming that there are many elements used in relation to self-directed learning, classification is needed to organize the analysis and discussion in this meta-review (Kleibergen, 2005). So far, there has been no real classification of elements that support self-directed learning (Lemmetty & Collin, 2020; Tekkol & Demirel, 2018). Therefore, the primary goal of this study is to obtain a comprehensive view of these elements. To achieve this, a systematic meta-review on self-directed learning was conducted to define the elements that stimulate independence. The secondary goal is to identify the key elements of self-directed learning that should be integrated into ubiquitous learning environments for adult learners in their workplaces. To do this, essential elements for ubiquitous learning environments were identified using literature studies. Subsequently, these elements were matched with elements of self-directed learning.

While technology has great potential to support workplace learning, an approach that combines technology with andragogical principles, such as supportive social and physical environments and attention to internal/psychological events, will be more effective in creating lifelong learners. Technology should be seen as a tool that enriches the learning experience, not replaces it. By better understanding the elements that support self-directed learning and how they can be integrated into ubiquitous learning environments, we can create a more holistic and adaptive approach to adult education.

METHOD

The research approach utilizes quantitative methods to statistically measure and analyze how andragogical concepts and technology are applied in adaptive learning within adult education (Apuke, 2017; Felson, 2017). The research design employed is a survey, which will collect data from a large number of respondents regarding the implementation of andragogy and technology in adult education, allowing for the measurement of perceptions and experiences on a broader scale (Moser & Kalton, 2017). The research population consists of prospective adult educators who have implemented technology in their teaching. The sample will be selected using stratified random sampling techniques to ensure proportional representation of the population, totaling 659 respondents, with the sample size determined using the Slovin's formula $n = \frac{N}{1+N(e^2)}$ (Berndt, 2020).

$$n = \frac{659}{1 + 659(0,05^2)} = 249$$

Table 1. Research Constructs and Indicators

Variable	Indicator
Adaptive Technology Implementation (X1)	Technology Accessibility
	Personalized Learning
	Interactivity
	System Integration
Andragogical Learning and Assessment Strategies (Y)	Problem-Based Learning
	Self-Directed Learning
	Continuous Feedback and Evaluation
	Contextual Learning

Based on the table, the research hypotheses are as follows:

Ho: The implementation of Adaptive Technology does not have a significant impact on Andragogical Learning Strategies and Assessment.

Ho: $\beta = 0$

Ha: The implementation of Adaptive Technology has a significant impact on Andragogical Learning Strategies and Assessment.

Ha: $\beta \neq 0$

The survey instrument, designed based on validated constructs and indicators, will measure variables such as technology accessibility, personalized learning, interactivity, and problem-based learning strategies. Hypotheses will be tested using multiple regression analysis to assess the significance of adaptive technology's influence on andragogical strategies. Reliability and validity of the instrument will be ensured through Cronbach's Alpha and factor analysis, while ethical standards such as informed consent and confidentiality will be upheld. The findings are expected to provide valuable insights into optimizing adult education through the integration of adaptive technology, offering practical implications for educators and policymakers.

RESULTS AND DISCUSSION

Structural Equation Modeling (SEM) is used to test the relationships between multiple latent variables while minimizing estimation errors. SEM allows researchers to examine both direct and indirect relationships among complex variables, providing a deeper understanding of the causal relationships between them. In the context of this research, SEM is used to test whether the implementation of adaptive technology (a latent variable) has a significant impact on andragogical learning strategies and assessment (another latent variable), while controlling for related indicators such as technology accessibility, personalized learning, interactivity, and system integration for adaptive technology, as well as problem-based learning, self-directed learning, continuous feedback and evaluation, and contextual learning for andragogical strategies. Before data analysis, the validity and reliability of the structured test instruments were assessed. The validity test results showed that all question items had significant validity values ($p < 0.05$). Reliability and validity were measured using Cronbach's Alpha, rho_A, Composite Reliability, and Average Variance Extracted (AVE).

Table 2. Validitas dan Reliabilitas

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
AL	0.521	0.529	0.735	0.411
IAT	0.516	0.535	0.732	0.408

A Composite Reliability value above 0.7 indicates good reliability, while an AVE (Average Variance Extracted) value above 0.5 is generally considered sufficient for convergent validity. However, in this case, some AVE values fall below this threshold, indicating that certain indicators may need improvement. This suggests that the model may not fully capture the underlying constructs and that some items might not be adequately representing the intended latent variables. The Composite Reliability value above 0.7 indicates good reliability, while an AVE value above 0.5 is generally considered adequate for convergent validity. However, in this case, some AVE values fall below this threshold, indicating that certain indicators may need improvement. Next, the VIF (Variance Inflation Factor) is used to check for multicollinearity among the indicators. The following are the VIF values for each indicator:

Table 3. Multikolinearitas

	VIF		
CFE	1.169	AL	IAT
CL	1.108	AL	
I	1.096	IAT	1
PBL	1.084		
PL	1.166		
SDL	1.116		
SI	1.091		
TA	1.102		

A VIF value below 5 indicates that there are no significant multicollinearity issues in the model. Model fit demonstrates the extent to which the model aligns with the observed data. The low VIF values observed in Table 3 suggest that multicollinearity is not a concern, ensuring the stability and interpretability of the regression coefficients.

Tabel 4. Model Fit Summary

	Saturated Model	Estimated Model
SRMR	0.03	0.03
d_ULS	0.482	0.482
d_G	0.097	0.097
Chi-Square	128.243	128.243
NFI	0.784	0.784

Table 4 provides a summary of the model fit, which includes several important metrics for evaluating the model's performance. Overall, this model shows a reasonably good fit with the observed data based on the SRMR and NFI values. However, to further improve the model fit, this study aims to consider revisions or refinements to achieve a higher NFI value. This could involve re-evaluating the measurement items, improving the construct definitions, or exploring alternative model specifications. By addressing these areas, the model's explanatory power and overall fit are expected to improve, leading to more reliable and valid conclusions.

Adaptive Technology Implementation has a positive and significant impact on Andragogical Learning and Assessment Strategies. The path coefficient of 0.608 indicates a significant influence of IAT on AL, suggesting that IAT makes a strong positive contribution to AL. This strong path coefficient underscores the effectiveness of integrating adaptive technology in enhancing andragogical approaches, demonstrating its crucial role in improving adult education outcomes. As a result, educators and policymakers should consider prioritizing the implementation of adaptive technologies to foster more effective and personalized learning experiences for adult learners.

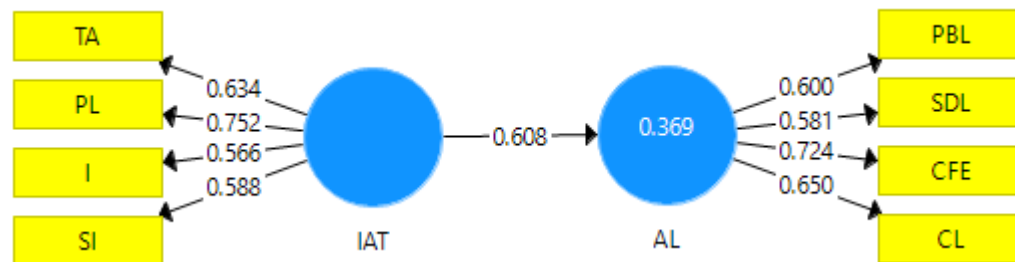


Figure 1. Path Coefficients Model

These outer loadings values indicate that all the listed indicators have outer loadings above the 0.5 threshold, suggesting that they adequately contribute to their respective constructs. This confirms the reliability and validity of the measurement model, with each indicator effectively capturing the essence of the construct it is intended to measure.

Table 5. Outer Loadings

	AL	IAT
CFE	0.724	
CL	0.650	
I		0.566
PBL	0.600	
PL		0.752
SDL	0.581	
SI		0.588
TA		0.634

R Square and F Square are important metrics in regression analysis. R Square indicates the proportion of variance in the dependent variable that is explained by the independent variables. F Square, on the other hand, is used to measure the effect size of each independent variable in the model. Table 6 provides the detailed values of R Square, Adjusted R Square, and F Square for the AL construct.

Table 6. R Square and F Square

	R Square	R Square Adjusted	F
AL	0.369	0.367	0.585

An R Square value of 0.369 indicates that 36.9% of the variance in the AL construct can be explained by the independent variables in the model. The Adjusted R Square value of 0.367 provides an estimate that has been adjusted for the number of predictors in the model, offering a more accurate estimation of the proportion of variance explained. An F Square value of 0.585 indicates a substantial effect size of the independent variables on the AL construct.

The implementation of adaptive technology in adult education significantly contributes to andragogical learning strategies. Adaptive technology, which includes technology accessibility, personalized learning, interactivity, and system integration, allows educators to tailor learning materials and methods to the needs and abilities of individual learners (Marienko et al., 2020). Azorín (2022) emphasizes the importance of international collaboration in education to enhance learning and teaching. The implementation of adaptive technology can expand access to resources and best practices through collaborative networks, supporting personalization and contextual relevance in andragogical learning (Abri et al., 2020; Cristea & Ghali, 2011).

Adaptive technology also facilitates self-directed learning by providing easy access to educational resources and interactive learning tools, as demonstrated by Bîrsanu (2020) in the context of e-learning. Fadieieva (2023) identifies that adaptive learning offers more targeted solutions to meet individual learner needs, supporting rapid feedback and continuous evaluation, helping learners to continuously improve their performance in real-time. Farmer (2010) highlights new perspectives in andragogy related to the use of technology, which provides effective tools for evaluating and guiding the adult learning process.

Ferreira and MacLean (2018) emphasize the importance of adult learning assumptions in the online context, showing that adaptive technology can create a dynamic and responsive learning environment for learners. Knowles (1984) states that modern adult education principles, such as self-directed learning and contextual relevance, are greatly enhanced by the application of adaptive technology. This technology supports adult educators in designing more effective and relevant learning methods. Kumar Basak et al. (2018) demonstrate that educational technology offers various ways to enhance engagement and learning outcomes, supporting the crucial role of adaptive technology in andragogical learning strategies. Adaptive technology facilitates problem-based learning by providing simulations, case studies, and analytical tools that learners can use to solve real-world problems. This aligns with the principles of problem-based and contextual learning.

Rahiem (2020) highlights the importance of addressing technological barriers in education during emergencies, underscoring the need for infrastructure that supports adaptive technology to ensure the necessary accessibility and interactivity for effective learning. Overall, adaptive technology not only enriches andragogical learning strategies but also enables faster and more effective adaptation to individual learner needs, supporting more relevant and contextual learning, and enhancing continuous evaluation and feedback. The research results have several practical implications for adult educators and educational institutions. Educational institutions need to provide adequate training for educators in using adaptive technology and integrating it with andragogical strategies. Additionally, it is essential to ensure that the technological infrastructure in educational institutions supports the accessibility, personalization, and interactivity required for adaptive learning.

Educators also need to continuously evaluate and adjust their teaching methods based on feedback from learners and learning evaluation results. This research has several limitations that need to be considered. First, the study only involved adult educators from a few educational institutions, so the results may not be generalizable to all adult education contexts. Second, using surveys as a data collection method has limitations in revealing in-depth understanding of individual experiences. Future research should consider conducting more in-depth qualitative studies to explore the experiences and perceptions of adult educators regarding the implementation of adaptive technology and andragogy. Additionally, research can be expanded by involving more educational institutions from various regions to obtain more comprehensive results.

CONCLUSION

The implementation of adaptive technology in adult education significantly contributes to andragogical learning strategies. This technology enables personalized learning, enhances accessibility, and provides interactive platforms that support adult learning principles such as self-directed, problem-based, and contextual learning. Analysis of the relationships between constructs shows that IAT (Independent Variable) significantly contributes to AL (Dependent Variable) with a path coefficient of 0.608. High outer loadings values, such as PL on IAT and CFE on AL, indicate significant contributions of each indicator to their respective constructs. An R Square value of 0.369 for AL indicates that 36.9% of the variability in AL can be explained by IAT, though other variables not included in the model may also play a role. The implementation of adaptive technology facilitates more personalized, self-directed, and interactive learning, supporting continuous evaluation and problem-based learning. The findings show that adaptive technology enriches the learning process by providing rapid feedback and continuous evaluation, creating a learning environment responsive to individual learner needs. Therefore, to maximize these benefits, educational institutions need to ensure adequate technological infrastructure and provide training for educators to integrate adaptive technology into their andragogical learning strategies.

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