Evaluation of GeoGebra Implementation in Schools: A Combined TAM and IS Success Model Approach

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***Abstract*—This study evaluates the implementation of GeoGebra in mathematics education by integrating the Technology Acceptance Model and the Information Systems Success Model. The hybrid model enables a multifaceted assessment, capturing both user acceptance and the broader organisational impacts of the technology. Quantitative data, gathered through surveys and statistical analysis, measures GeoGebra adoption, perceived usefulness, and ease of use among teachers and students. Qualitative data, collected through interviews, focus groups, and classroom observations, provides insights into the experiences of teachers and students using GeoGebra. Data analysis involves descriptive and inferential statistics to compare user perceptions and examine the relationships between variables, such as the impact of perceived usefulness and system quality on user satisfaction and behavioural intention. The findings offer practical consequences for educational institutions and mathematics teachers wishing to successfully incorporate GeoGebra into their mathematics curriculum by addressing technical complexity and providing sufficient assistance.**

Keywords—Technology Acceptance, IS Success, Mathematics, Technology, GeoGebra

I. Introduction

The integration of technology into educational settings has spurred the adoption of various software tools aimed at enhancing the learning experience, with GeoGebra emerging as a prominent example in the realm of mathematics education [1]. GeoGebra, designed specifically for learning geometry and algebra, has gained traction as an open-source software for increasing online learning engagement and attractiveness [2]. In light of South Africa's performance in international mathematics assessments, such as the Trends in International Mathematics and Science Study, the integration of GeoGebra is seen as a strategic move to enhance mathematics teaching and learning, ultimately upgrading student performance [1]. This strategic alignment with national objectives underscores the importance of evaluating not only the adoption of GeoGebra but also its overall success and impact within the educational system.

The Technology Acceptance Model and the Information Systems Success Model provide complementary frameworks for evaluating the acceptance and success of technology implementations [3]. The Technology Acceptance Model posits that perceived usefulness and perceived ease of use are primary determinants of technology acceptance [3]. Specifically, suppose users perceive a technology as useful and easy to use. In that case, they are more likely to develop a positive attitude towards it, which in turn influences their intention to adopt and use the technology [4], [5]. External factors, such as support, also play a role [4]. The Information Systems Success Model expands its scope by incorporating dimensions such as system quality, information quality, and service quality as determinants of user satisfaction, which in turn influence individual and organisational impact. The alignment of TAM and ISS models provides a holistic approach. It allows for a comprehensive evaluation framework that captures both user-centric and system-centric perspectives on the success of GeoGebra implementation.

To provide a more nuanced evaluation of GeoGebra's implementation, a hybrid model integrating TAM and the IS Success Model can be employed. Such a model would enable a multifaceted assessment, capturing both user acceptance and the broader organisational impacts of the technology [4], [6], [7]. This approach acknowledges that individual acceptance does not solely determine the success of technology in education but is also influenced by the quality of the system, the information it provides, and the support services available [8]. By integrating these two established models, the evaluation framework can give actionable insights for optimising GeoGebra implementation strategies, maximising its impact on mathematics education and student outcomes.

II. Literature Review

The Technology Acceptance Model, developed by Davis, is used to determine the acceptance, adoption, and utilisation of information technology [9]. TAM posits that the intention to use a technology is primarily influenced by two key beliefs: perceived usefulness and perceived ease of use [10]. Perceived usefulness refers to the degree to which an individual believes that using a particular technology will enhance their job performance, while perceived ease of use relates to the extent to which an individual believes that using a specific technology will be free of effort [7], [9], [11]. TAM is effective in predicting the users' intention to use Information Technology. Both perceived usefulness and perceived ease of use are influenced by external factors, such as training, support, and system characteristics, which can either facilitate or hinder technology adoption.

The IS Success Model broadens the scope of evaluation by considering multiple dimensions of system quality, information quality, and service quality as determinants of user satisfaction and overall system success. System quality refers to the technical aspects of the system, including its reliability, responsiveness, and ease of navigation. Information quality pertains to the accuracy, completeness, and relevance of the information provided by the system. Service quality encompasses the level of support and assistance provided to users, including training, documentation, and technical support.

Studies have also modified the Technology Acceptance Model (TAM) to align with their research and obtain accurate results, including adaptations to the TAM that were initially based on the study’s purpose and sample [12], [13]. It has been shown that TAM for information technology is not sufficient from an individual standpoint but must also be considered from an organisational perspective, for example, by looking at the actual work conditions [12], [14], [15].

III. Method

Evaluating the success of GeoGebra implementation in schools necessitates a robust research methodology that combines quantitative and qualitative approaches. A quantitative approach, utilising surveys with 320 respondents and statistical analysis, can measure the extent of GeoGebra adoption, as well as its perceived usefulness and ease of use, among teachers and students. Structural equation modelling is employed to identify the relationship between variables [16], [17]. Moreover, quantitative data can be gathered on student performance metrics, such as test scores and grades, to assess the direct impact of GeoGebra on learning outcomes. Qualitative data, collected through interviews, focus groups, and classroom observations, can provide richer insights into the experiences of teachers and students using GeoGebra, capturing the nuances of how the software is integrated into teaching practices and learning activities.

The conceptual model in this research is developed by integrating the Technology Acceptance Model (TAM) and the DeLone and McLean IS Success Model. This model, presented in Figure 1, aims to explain the relationship between system quality, perceived ease of use, usefulness, user attitudes, and the ultimate impact on net benefits in the context of information systems or digital technology usage, particularly in educational or professional environments. First, Perceived Usefulness (PU) is influenced by two main variables: Perceived Ease of Use (PEU) and Information Quality (IQ). This means that the easier a system is to use, and the higher the quality of the information provided (in terms of accuracy, relevance, and clarity), the higher the perception that the system is beneficial for its users. This aligns with the basic assumption of TAM that ease of use enhances the perception of the usefulness of technology. Next, Perceived Ease of Use (PEU) is directly influenced by System Quality (SYQ), which includes aspects such as system stability, response speed, and ease of navigation. When a system is technically assessed as high quality, users tend to find it easier to use, which ultimately strengthens technology adoption. Attitude Toward Using (ATU) is influenced by PU and PEU. When users feel that the system is useful and easy to use, they are likely to develop a positive attitude toward its use. This positive attitude plays a crucial role in shaping behavioural intention. Behavioural Intention to Use (BIU) is influenced by PU and ATU. This reflects that the perception of usefulness not only shapes attitudes but also directly drives a person's intention to use the system.

Additionally, a positive attitude toward the system reinforces the user's commitment to continue utilizing it. Furthermore, User Satisfaction (US) is influenced by four variables: BIU, Information Quality (IQ), Service Quality (SQ), and System Quality (SYQ). Satisfaction is formed not only from the desire and intention to use the system but also from the actual experience regarding the quality of information, support services, and overall system performance. Information and system quality ensure that users receive the expected benefits, while service quality guarantees responsive support in using the system. Finally, Net Benefits (NB) as the ultimate outcome of user interaction with the system is influenced by User Satisfaction (US). When users feel satisfied, the system will provide tangible benefits, whether in the form of improved performance, efficiency, better decision-making, or overall job or learning satisfaction. This reflects the success of the information system in delivering significant added value. This model provides a comprehensive overview of the process of forming the benefits of information systems, from technical and informational quality, user perceptions, attitudes, to the final impact. Thus, this model is relevant for assessing the effectiveness of technology adoption in various implementation contexts.

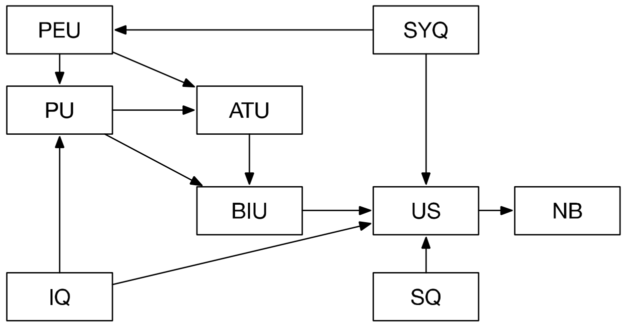

Fig. 1. The Combination of the TAM and the IS Success Model

The research began by defining the research program, followed by the development of a model based on previous studies, and concluded with the presentation of results and discussions. In the context of the research, the measurement model was designed based on a modified Technology Acceptance Model (TAM) framework that included the dimensions of instructor support and self-efficacy. The items used to measure each variable were adapted from prior studies and were assessed using a five-point Likert scale, ranging from "strongly disagree" to "strongly agree." The research variables included perceived ease of use, perceived usefulness, GeoGebra self-efficacy, teacher support, attitude toward using GeoGebra, and behavioural intention to use GeoGebra.

Data analysis should involve both descriptive and inferential statistics to draw meaningful conclusions. Descriptive statistics such as mean, median, and standard deviation can be used to summarise the demographic characteristics of the sample and the distribution of responses to survey items. Inferential statistics, such as t-tests, can be employed to compare the perceptions and attitudes of different groups of users, such as teachers with varying levels of experience or students from various grade levels.

Furthermore, regression analysis can be used to examine the relationships between the variables in the integrated TAM and IS Success Model, such as the impact of perceived usefulness and system quality on user satisfaction and behavioural intention.

IV. Result and Discussion

Based on data analysis, the use of GeoGebra showed favourable impacts on student motivation and attention [18]. For example, one study shows that students in the experimental group demonstrated a clear understanding of the material, and they showed tremendous conceptual understanding and optimum engagement in interactive activities [19]. The integration of GeoGebra into mathematics education presents an opportunity to engage students actively in their learning process [20]. Students become active participants in constructing their knowledge through exploration, experimentation, and problem-solving, and this method fosters a deeper understanding of mathematical concepts and enhances their critical thinking skills.

The study's findings can offer important practical implications for educational institutions and mathematics teachers. For schools to successfully incorporate GeoGebra into their mathematics curriculum, the results emphasise the importance of addressing technical complexity and providing sufficient support [21]. Teachers may need thorough training and ongoing support to effectively integrate GeoGebra into their lessons if students are to have a positive experience with the program [22]. Furthermore, the findings imply that initiatives aimed at increasing students' confidence in their ability to use GeoGebra, as well as fostering a positive attitude toward the technology, can improve adoption rates and learning outcomes [23]. The study emphasises the importance of considering the interplay between various elements, including user perceptions, system quality, and support services, when assessing the efficacy of technology integration in educational settings.

TABLE I. Operational of Variables

Variable	Indicator	Questionnare Statement
Perceived Usefulness (PU)	PU1	Using GeoGebra improved my performance in teaching/learning mathematics.
	PU2	GeoGebra helps me complete math tasks faster.
	PU3	I find GeoGebra useful in the mathematics learning process.
Perceived Ease of Use (PEU)	PEU1	I easily learned how to use GeoGebra.
	PEU2	The instructions and the appearance of GeoGebra are clear and easy for me to understand.
	PEU3	I feel comfortable and not frustrated when interacting with GeoGebra.
Attitude Toward Using (ATU)	ATU1	I feel good about using GeoGebra in math learning.
	ATU2	I believe GeoGebra can bring significant benefits to my scholar
	ATU3	I am eager to continue exploring GeoGebra for my scholar.
	ATU4	I feel confident in using GeoGebra.
Behavioral Intention to Use (BIU)	BIU1	I plan to continue using GeoGebra in math learning in the future.
	BIU2	I would recommend GeoGebra to other fellow teachers/students.
System Quality (SYQ)	SYQ1	GeoGebra is stable and rarely experiences technical problems.
	SYQ2	GeoGebra is responsive to the input I provide.
Information Quality (IQ)	IQ1	The information generated by GeoGebra is accurate and reliable.
	IQ2	The information provided by GeoGebra is relevant to my learning needs.
Service Quality (SEQ)	SEQ1	GeoGebra's support team was responsive to the questions and issues I encountered.
	SEQ2	The training I received on GeoGebra was adequate to help me use it effectively.
User Satisfaction (US)	US1	I am satisfied with my experience using GeoGebra.
	US2	GeoGebra met my expectations in helping the math learning process.
Net Benefits (NB)	NB1	The use of GeoGebra improved my understanding of mathematical concepts.
	NB2	Using GeoGebra helped me solve math problems more efficiently.
	NB3	The use of Geogebra increases students' motivation to learn as well as students' conceptual understanding

Table 2 shows the extent to which exogenous variables can explain the variation of each endogenous variable in the structural model. The R Square value for the Attitude Toward Using (ATU) construct is 0.594, indicating that approximately 59.4% of the variation in users' attitudes toward using GeoGebra can be explained by the Perceived Usefulness (PU) and Perceived Ease of Use (PEU) constructs. Furthermore, the Behavioural Intention to Use (BIU) construct has an R Square of 0.677, meaning that 67.7% of the variation in users' behavioural intention to use GeoGebra is influenced by the attitude construct (ATU). The User Satisfaction (US) construct recorded an R Square value of 0.653, indicating that 65.3% of the variation in user satisfaction with GeoGebra is influenced by system quality, information quality, and service quality. Meanwhile, the Net Benefits (NB) construct has the highest R Square value of 0.739, indicating that the model successfully explains 73.9% of the variation in net benefits derived from using GeoGebra, which comes from the influence of user satisfaction and behavioural intention. Overall, the R Square values obtained fall within the moderate to strong category, indicating that the model has good predictive power in explaining the endogenous variables studied.

TABLE II. R Square and R Square Adjusted

Variable	R Square	R Square Adjusted
Attitude Toward Using (ATU)	0.594	0.590
Behavioral Intention to Use (BIU)	0.677	0.672
User Satisfaction (US)	0.653	0.648
Net Benefits (NB)	0.739	0.735

Based on Table 3, all constructs in the model show very good reliability values. The Cronbach's Alpha values for all constructs are above the minimum threshold of 0.7, indicating internal consistency among indicators within each construct. The Net Benefits (NB) construct has the highest Cronbach's Alpha value of 0.862, which indicates that the items in this construct consistently measure the dimension of net benefits derived from the use of GeoGebra. Furthermore, the Rho_A values for all constructs also exceed the threshold of 0.7, supporting the conclusion that convergent reliability has been achieved. The Composite Reliability (CR) values range from 0.860 to 0.915, indicating that each construct has strong construct reliability and can consistently reflect its latent variables. These results show that all items in the questionnaire used have met the reliability standards, making them suitable for further analysis in a valid and accurate manner.

TABLE III. CRONBACH'S ALPHA, RHO_A, AND COMPOSITE RELIABILITY

Variable	Cronbach's Alpha	rho_A	Composite Reliability
PU	0.829	0.835	0.894
PEU	0.841	0.846	0.902
ATU	0.865	0.871	0.912
BIU	0.775	0.780	0.872
SYQ	0.788	0.795	0.874
IQ	0.781	0.784	0.868
SEQ	0.758	0.761	0.860
US	0.815	0.819	0.888
NB	0.862	0.868	0.915

The results of the path analysis in Table 4 indicate that all relationships between constructs in the model are highly statistically significant, as evidenced by t-statistic values exceeding 1.96 and p-values less than 0.05. The relationship between Perceived Ease of Use (PEU) and Perceived Usefulness (PU) has a coefficient of 0.456 with a t-statistic of 7.881, indicating that the perception of ease of use of GeoGebra significantly enhances the perception of the system's usefulness. Furthermore, both PU ($\beta = 0.472$) and PEU ($\beta = 0.298$) significantly influence Attitude Toward Using (ATU), which then greatly contributes to Behavioural Intention to Use (BIU) ($\beta = 0.522$). In the context of system quality, System Quality (SYQ), Information Quality (IQ), and Service Quality (SEQ) each make significant contributions to User Satisfaction (US), with the largest influence coming from SYQ ($\beta = 0.327$). Regarding Net Benefits (NB), the main influence comes from User Satisfaction ($\beta = 0.581$), followed by Behavioural Intention ($\beta = 0.319$). These findings indicate that user satisfaction and intention to use are the main determinants in achieving net benefits from using GeoGebra.

TABLE IV. PATH COEFFICIENT, T-STATISTIC, AND P-VALUE

Variable	Path Coefficient	t-statistic	P-value
PEU → PU	0.456	7.881	<0.001
PU → ATU	0.472	6.491	<0.001
PEU → ATU	0.298	4.512	<0.001
ATU → BIU	0.522	7.998	<0.001
SYQ → US	0.327	5.112	<0.001
IQ → US	0.291	4.207	<0.001
SEQ → US	0.213	3.322	0.001
US → NB	0.581	9.028	<0.001
BIU → NB	0.319	5.621	<0.001

Overall, all hypotheses in the model are accepted, and the developed structural model demonstrates strong empirical validity and theoretical coherence in explaining the factors that influence the utilisation of GeoGebra in mathematics learning. To empirically validate the research model and test the proposed hypotheses, a rigorous statistical approach was adopted, involving Confirmatory Factor Analysis for assessing the measurement model and Structural Equation Modelling for evaluating the structural relationships [24].

V. CONCLUSION

This study contributes to the literature by integrating the Technology Acceptance Model and the Information System Success Model to evaluate the success of GeoGebra implementation in schools. By investigating the interrelationships between perceived usefulness, perceived ease of use, system quality, information quality, service quality, user satisfaction, and behavioural intention, this research provides a holistic understanding of the factors that influence the adoption and effectiveness of GeoGebra in educational settings. The findings reveal that perceived usefulness and perceived ease of use are significant determinants of students' attitudes toward using GeoGebra, which in turn affects their behavioural intention to use the software [25]. This corroborates previous research indicating that perceived usefulness, perceived ease of use, and trust have a significant positive influence on behavioural intention [26]. Furthermore, the study demonstrates that system quality, information quality, and service quality significantly impact user satisfaction, which subsequently leads to net benefits in terms of improved learning outcomes and enhanced teaching experiences. The study also demonstrates the influence of external factors, such as government support, on shaping attitudes towards technology [4]. The results of this study are consistent with previous research that highlights the importance of user satisfaction and behavioural intention in achieving net benefits from technology adoption [4].

Additionally, the research findings align with previous studies that emphasise the significant role of perceived usefulness and perceived ease of use in shaping user attitudes and behavioural intentions [4]. The implications of these findings are manifold, offering actionable insights for educators, policymakers, and software developers. By understanding the critical factors that drive GeoGebra adoption and success, educators can design more effective technology integration strategies that enhance student learning outcomes. Administrators can allocate resources to improve system quality, information quality, and service quality, thereby increasing user satisfaction and maximising the benefits of GeoGebra implementation [27]. Software developers can leverage these insights to enhance the design and functionality of GeoGebra, making it more user-friendly and aligned with the needs of educators and students.

Moreover, the integrated model developed in this study provides a robust framework for evaluating the success of technology implementation in various educational contexts, beyond just GeoGebra. The study confirms that perceived ease of use has a tangible impact [28]. This model can be adapted and applied to assess the effectiveness of other educational technologies and inform evidence-based decision-making in educational technology initiatives. While this study offers valuable insights, it is important to acknowledge its limitations. Future research could investigate the moderating effects of demographic variables, such as gender, age, and prior experience with technology, on the relationships between the model's constructs. Additionally, longitudinal studies could be conducted to examine the long-term impact of GeoGebra implementation on student learning outcomes and teacher professional development. Future studies should include longitudinal data collection to evaluate changes in user perceptions and behaviours over time, providing a more comprehensive understanding of the long-term impact of GeoGebra implementation.

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