Development of the SmartJawi App: An Interactive Learning Tool for Children Aged 4–5 Years Old

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***Abstract*—The traditional script known as Jawi, used in the Malay language, is a key aspect of the cultural and linguistic heritage of Malay speakers. However, the declining use of Jawi in modern education has raised concerns with regard to children's exposure to the script and their competence in its use, especially at the kindergarten level. Thus, the current study aimed to develop and test an innovation, the SmartJawi App, to enhance the learning motivation of children aged 4 to 5 during Jawi Education in early childhood education settings. The study was developed according to the Design and Development Research (DDR) paradigm, which involved a multilateral approach and was conducted in three phases. Phase 1 involved a needs assessment that included semi-structured interviews with three kindergarten educators to identify current pedagogical problems. Meanwhile, Phase 2 included developing the SmartJawi App, with three subject-matter experts involved in the process. Moreover, Phase 3 evaluated the application's effectiveness through a six-week intervention involving one kindergarten educator and nine preschool children. The findings revealed that the SmartJawi App positively affected children's learning motivation. Additionally, the application's interactive elements contributed to higher levels of reading and writing skills among young learners. This study also highlights the potential of digital educational tools to support early literacy and preserve linguistic heritage. Overall, the results suggest that SmartJawi App can serve as an effective supplementary resource for kindergarten Jawi instruction.**

***Keywords*—early childhood education, educational technology, learning motivation, Jawi literacy**

I. Introduction

The Jawi script is a key aspect of the Malay cultural heritage and a strong determinant of the history of education and literary directions [1, 2]. Although conservation programs have been established through learning institutions and cultural policy systems, the main concern is determining how Jawi literacy should be taught to kindergarteners in line with their cognitive development [3, 4].

The modern digital generation is becoming increasingly conversant with interactive technologies, thus making traditional instructional strategies ineffective in developing Jawi literacy as part of Malay identity formation. As educational technology has evolved [5–7], gamified learning environments using animation, real-time feedback, and game-based interactive activities have demonstrated improvements in children's motivation and academic achievement. Despite this, empirical research indicates that explicit digital resources to meet Jawi literacy requirements are limited and insufficient to meet the unique needs of a kindergartener [8, 9].

In the Self-Determination Theory (SDT) framework [10, 11], a child's motivational involvement in their learning process is strongly influenced by how closely instructional activities align with the basic psychological needs of autonomy, competence, and relatedness. However, the formation of intrinsic motivation is severely limited when the design of teaching materials fails to provide choice, a sense of competence regarding skills, and the ability to interact in a meaningful way [12]. Consequently, the digital learning tools used to facilitate Jawi literacy should be carefully developed to ensure that interactivity is not reduced to mere entertainment. Instead, these tools should serve as instruments for fostering intrinsic motivation, which is a prerequisite for successful learning in early childhood [13–15].

Furthermore, the current study contributes beyond Jawi literacy to global research on digital literacy and early language acquisition [16]. It is a good point of reference for different nations, as it identifies gaps uncovered through the analysis of technologically mediated education materials and how they affect children's learning. In this study, the main research question is "How simple and systematic applications may be built to help kindergarten children to be motivated, interactive, and cognitively ready in Jawi literacy?" It is expected that the SmartJawi App will achieve this goal by offering relevant Information and Communication Technology (ICT) tools. This, in turn, addresses the identified research gap and enhances digital literacy at an early stage.

II. Literature Review

According to preliminary studies, there is currently a proliferation of digital technology in Jawi learning, yet many applications designed for kindergarten-aged learners failed to address their developmental needs. In comparative analysis, reported improvement in basic Jawi skills can be credited to digital interventions. Nevertheless, most existing applications are generic and lack interactivity, raising concerns that they may become passive display devices that cannot effectively support early literacy development [8]. In addition, the promise of gamification and Artificial

Intelligence (AI) to enhance the pedagogical experience and contextualize content to the Malay milieu was also highlighted in an empirical investigation. Still, at present, the designs do not align with the cognitive profiles of children aged 4 to 5 years [3]. Concurrently, another study [17] proposed the development of accessible, interactive platforms to engage users with the Jawi script. Since it lacks a specific digital competency framework and strong methodological foundations, it is challenging to assess the effectiveness of these applications.

Notably, compared with the use of technology in Jawi literacy teaching, past studies reveal that the efficacy of technology interventions in early childhood pedagogy depends on the tool and pedagogical design, the level of interactivity, and the role of adults. For example, one study identified gaps in the theoretical base regarding the definition of digital competence [18]. Meanwhile, another reported that technological tools enhance interactive learning motivation only when children are supported by adults [19].

On the other hand, another key study highlighted a lack of educator readiness, attributed to insufficient practice and moral awareness [20]. In contrast, research has revealed that effective use of digital tools depends on the level of pedagogical knowledge and on the technology's ability to visualize abstract concepts [21]. Similarly, a study demonstrated that early-stage language applications can improve engagement and self-autonomy in learning. Nevertheless, their design must align with age-related principles and be accompanied by educator supervision [22, 23].

III. Materials and Methods

This study adopted a multi-method design [24] based on Design and Development Research (DDR) and was implemented in three major phases [25]. The first phase included semi-structured exploratory interviews [26] with early childhood educators who have at least five years' experience teaching children. This aims to identify the essential attributes of an application applicable in the kindergarten educational milieu. Following this, the second phase focused on expert consensus [27], in which the application was reviewed by a group of experts in education, technology, and literacy to achieve content validity, usability, and pedagogical appropriateness. Subsequently, the third phase was devoted to the assessment of the developed application [28] for kindergarten children aged 4 to 5 years, through exploratory experimentation [29].

Prior to conducting the exploratory study with nine kindergarten children aged 4 to 5 years, a pilot study was conducted with five children from another private kindergarten. The pilot lasted 4 weeks, with 2 hours per week dedicated to training in the Jawi script using SmartJawi. As such, the analysis of the data indicated an improvement in general learning motivation. In particular, the mean score increased during the period, from 56.4 in the pre-test to 63.4 in the test period, and the median score was 58 and 62, respectively. On the individual level, the scores consistently increased. Although the standard deviation has increased due to greater variability in participants' responses (2.88 to 9.04), these findings still posit a positive initial sign of the intervention's effectiveness. Although due to the small sample size, these results should be taken only as an indication of performance and not as inferential evidence for the population as a whole.

A. Samplings

The initial phase included semi-structured interviews with three educators, as qualitative research allows researchers to use small samples once data saturation is achieved [30]. The three educators participated in the interview sessions. Correspondingly, the second phase involved three experts: two specialists in early childhood education and one specialist in educational technology, each with at least a PhD and over five years of practical experience, in line with the principles of expert evaluation, which favor small yet authoritative panels [31].

Following this, the third phase entailed a privately conducted field experiment by a kindergarten educator on nine children. The selection of this sample was intended to reflect a real classroom environment to ensure that the intervention could be assessed on a small, controlled basis. In Malaysia, classes in private kindergartens usually include between 9 and 12 pupils, fewer than in government kindergartens. This is attributed to the fact that this arrangement facilitates a narrow-focused teaching method, a structured learning environment, and allows educators to devote more personalized attention to each child. Thus, the small sample can be explained by the fact that the implementation practices of kindergartens such as this are being implemented. Therefore, it is appropriate for exploratory research that examines differences between pre- and post-test scores [32].

B. Research Instruments

1) SmartJawi App needs for kindergarten children

IVForm: SmartJawi App Needs for Preschool Children (SMABPC) was designed around three major constructs that form the data-collection framework, each reflected in a separate item. Specifically, identification of issues and barriers in Jawi learning is the first construct, aimed at outlining the real problems educators and learners face in acquiring Jawi literacy. Then, the second construct, evaluation of existing teaching practices and strategies, analyses existing instructional practices and evaluates their effectiveness in encouraging kindergarteners to work with the Jawi script. In addition, the third construct is the determination of pedagogical needs and the functional features of the SmartJawi App. In essence, this construct emphasizes educators' and children's needs for the application and the main features that must be presented to ensure relevance. Note that each construct has only one item, specifically formulated to direct the interview toward significant findings.

2) SmartJawi App design and development evaluation

SmartJawi App Design and Development Evaluation Questionnaire (SJADDEQ) was developed with seven main constructs, each represented by two specific items. In particular, all of these items were formulated to elicit systematic feedback from respondents, ensuring that the application evaluation was comprehensive and well-directed. All constructs and related items are displayed in Table 1 as the main reference for implementing the questionnaire.

This questionnaire was answered by three field experts: An

expert in early childhood education, an educational psychologist, and an educational technologist. Each expert was asked to evaluate the items presented using a six-point Likert scale, starting from score 1 = Strongly Disagree (SD), Score 2 = Disagree (D), Score 3 = Somewhat Disagree (SWD), Score 4 = Somewhat Agree (SWA), Score 5 = Agree (A), and Score 6 = Strongly Agree (SA). The selection of this scale aims to provide a more nuanced evaluation space, allowing experts to express their level of agreement more accurately for each item in the SJADDEQ.

Table 1. Constructs and items in SJADDEQ

No.	Construct	Item
1.	Interface Design	1. Arrangement 2. Animations
2.	Content Design	1. Developmentally appropriate 2. Helps with basic understanding
3.	Usability	1. Easy to control 2. Easy and smooth navigation
4.	User Engagement	1. Maintain interest 2. Active involvement
5.	Technical Function	1. No technical problems 2. Smooth screen touch
6.	Pedagogical Suitability	1. In line with the national curriculum 2. Supporting Development
7.	Potential Use in Education	1. Teaching aids 2. Self-use or educator's help

3) Jawi learning motivation assessment instrument

Jawi Learning Motivation Assessment Instrument: Pre-Post Tests (JLMAIPP) was used in a pre-posttest design, including three constructs and 15 items related to learning motivation, as depicted in Table 2. This instrument was adapted from the Motivational Learning Model [33] and subsequently validated by two experts in the field. As a result, they achieved a Cohen's Kappa agreement value of $k = 1$, indicating very high agreement in the validity of the tool developed for working with children.

Table 2. Constructs and items in JLMAIPPR

No.	Construct	Item
1.	Social Persistence with Educator	1. Polite attention 2. Show work 3. Ask help 4. Communicate educator 5. Please educator
2.	Satisfaction in Jawi Learning	1. Smile joy 2. Show pride 3. Enjoy tasks 4. Excited new words 5. Happy success
3.	Quick Jawi Learning Ability	1. Solve problems 2. Self-confidence 3. Quick understanding 4. Guess answers 5. Handle tasks

Before the post-test was administered, participants completed a pre-test to assess their motivation to learn Jawi prior to participating in the eight-week intervention. Following this, the intervention for children using the SmartJawi App lasted 6 weeks (2 hours per week). At the end of the intervention period, a post-test was conducted to determine how children's learning motivation could be measured. This allowed for a comparison of pre- and post-test scores to determine the effectiveness of the SmartJawi App.

C. Data Collection

This research was conducted in three separate phases, each with outlined timelines and methodological steps. The first phase was between early and late March 2025. Meanwhile, the second phase ran from early April to late June 2025 and included the development of the SmartJawi App and expert evaluation. Lastly, the final phase was implemented between early August and mid-September 2025, which involved classroom application. Notably, the appointment form was assigned to all the involved experts and educators and contained the code [KIAS/HEA/0.6/00/13] issued by the Research Management Center (RMC) of the University College. In Phase 3, parents or legal guardians provided consent on behalf of the children who agreed to participate in the study and submitted feedback through parental consent forms, thereby permitting their involvement in the six-week intervention.

D. Data Analysis

These study instruments were subjected to both face and content validation by two field experts. The Cohen's Kappa coefficient was 1.00, indicating perfect agreement and confirming the suitability of the instruments for all phases of the study. In the first phase, qualitative data from teachers were recorded, transcribed verbatim, and analyzed by the teachers themselves to ensure accuracy. The data were then thematically analyzed using ATLAS.ti, with an iterative coding method applied to maintain consistency. In the second phase, assessment responses were collected and organized in Excel spreadsheets. Accordingly, reliability was calculated using the Item-Content Validity Index (I-CVI) approach. The third phase consisted of a three-week pilot testing of the SmartJawi App in various kindergartens. The pilot results demonstrated an improvement in children's learning motivation, with pre-intervention scores of 3 to 4 out of 6 increasing to 4 to 6 out of 6. Specifically, quantitative data analysis was conducted using Statistical Package for the Social Sciences (SPSS), a one-way analysis of variance (ANOVA)applied to compare mean scores across the treatment groups. Remarkably, the findings confirmed that the intervention had a statistically significant effect. Overall, the process validated the reliability, content validity, and effectiveness of the SmartJawi App in enhancing Jawi learning motivation among preschool children.

IV. Result

A. RQ1: What is the Need to Develop a SmartJawi App for 4–5-year-old Children?

Fig. 1 illustrates the 3 main constructs discussed in answering the first research question. In discussing the challenges educators face in teaching kindergarten children to learn Jawi, a thematic analysis using ATLAS.ti identified three main issues. One of the most challenging aspects of learning Jawi is recognizing letters with almost identical shapes.

The analysis of developing the SmartJawi App revealed that the main limitation in early Jawi literacy among children aged 4 to 5 is the inability to discriminate the near-similar morphologies of letters visually. This is not simply a technique error. Instead, it is a vital hindrance to mastering the simple symbols of language, thereby hampering the smooth development of reading and writing. Building on this,

graphemes that differ in position (such as *ba, ta, tsa* – a few of the Jawi scripts) cannot be distinguished, and they require pedagogical interventions focused on training conscious visual recognition and on multimodal support to improve learning accuracy.

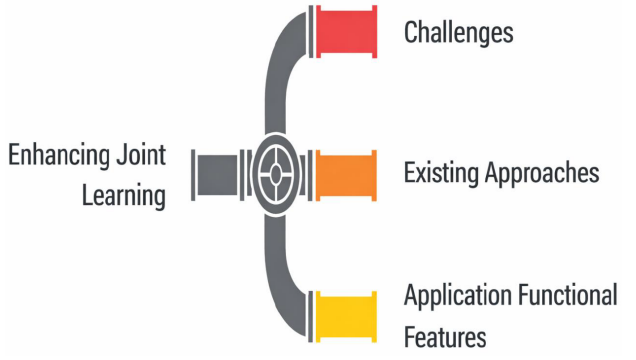

Fig. 1. Phase 1: Needs analysis for SmartJawi App.

Moreover, from a pedagogical perspective, qualitative data indicate that scaffolding, defined as incremental instructional support, is the most effective modality for alleviating cognitive complexity. This didactic framework follows hierarchical progression: first, it builds learners' awareness of the orthographic expression of a single grapheme, then shifts to more complex syllabic and lexical structures. As such, the role of digital platforms that act as facilitators is essential in this context, as they can ease learners' cognitive load by providing structured, sequenced instruction. Hence, this facilitates the development of a firmer foundation of preliminary proficiency in letter recognition.

As a result, the SmartJawi App development process incorporates a guided activity model as its primary functionality to ensure gradual mastery of literacy. The structure of this operation includes recognition training, dot-to-dot writing, and the orderly introduction of simple words, a method necessary for developing a sense of self-confidence and motivation in children. From an analytical perspective, integrating planned learning, regulated repetition, and the staged mastery theories into the application process streamlines the teaching process and serves as a cognitive trigger. This approach ensures that Jawi literacy is acquired more effectively and systematically than in traditional approaches.

B. *RQ2: Do Experts Agree with the Features and Functions Developed in the SmartJawi App?*

To answer the second research question, the researchers developed a SmartJawi App specifically designed to support the learning of the Jawi script among kindergarteners. The application foregrounds three main characteristics as illustrated in Fig. 2. These include a sequenced, scaffolded guidance system to facilitate staged learning, interactive modules to increase children's engagement, and formalized training routines that systematically help children master Jawi orthography, letters, syllables, and words. Notably, the combination of these features strengthens children's motivation and promotes the effectiveness of instruction in early childhood learning settings.

Table 3 summarizes the experts' responses to the seven constructs and 14 items (see Table 1). Based on the six-point Likert scales outlined in the sub-section of the Research Instrument: SJADDEQ, the data indicates that most items received ratings of SWA, A, or SA. This is a favorable professional approval of the design, usability, and pedagogical relevance of the SmartJawi App.

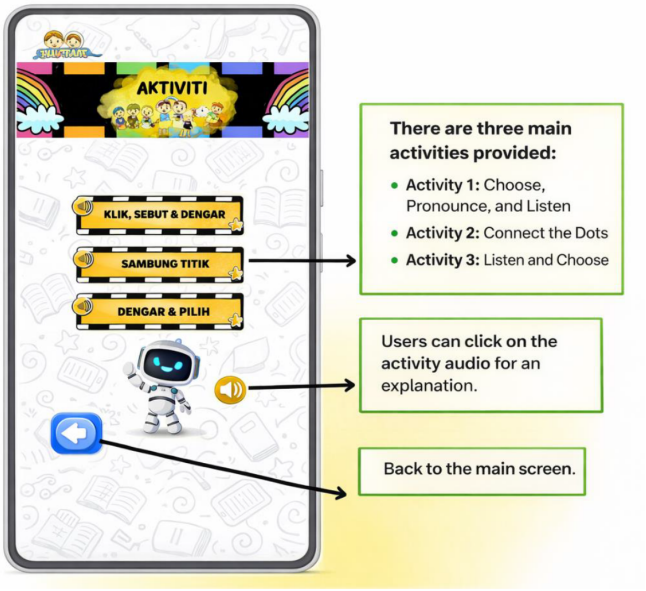

Fig. 2. A developed SmartJawi App.

Table 3. Expert agreement levels on item relevance and construct adequacy for the SmartJawi App

Construct	Item	Expert 1	Expert 2	Expert 3
1	1	A	SA	SA
	2	SWA	SA	A
2	1	A	SA	SA
	2	A	SA	SA
3	1	A	SA	A
	2	A	SA	SA
4	1	SWA	SA	SA
	2	A	SA	SA
5	1	A	SA	A
	2	A	SA	A
6	1	S	SA	SA
	2	S	SA	SA
7	1	S	S	SA
	2	S	S	SA

The concurrence with all items rated by experts was uniformly positive, with all items falling into Category 1, which includes SWA, A, and SA. However, no items were discovered in Category 0, the low-score category comprising SD, D, and SWD.

Table 4. Content Validity Index (I-CVI) and item relevance ratings by experts for the SmartJawi App assessment tool

Item	E1	E2	E3	I-CVI	Category	S-CVI
1	5	6	6	1	Relevant	1
2	4	6	5	1	Relevant	1
3	5	6	6	1	Relevant	1
4	5	6	6	1	Relevant	1
5	5	6	5	1	Relevant	1
6	5	6	6	1	Relevant	1
7	4	6	6	1	Relevant	1
8	5	6	6	1	Relevant	1
9	5	6	5	1	Relevant	1
10	5	6	5	1	Relevant	1
11	5	6	6	1	Relevant	1
12	5	6	6	1	Relevant	1
13	5	5	6	1	Relevant	1
14	5	5	6	1	Relevant	1

To determine content validity of the instrument, the item-level Content Validity Index (I-CVI), Scale-level

Content Validity Index (S-CVI), and an adjusted kappa statistic were calculated, after having dichotomized the six-point Likert scale to demarcate item suitability.

The results of analytic findings in Table 4 and Table 5 suggest that there is a strong inter-expert concordance with both I-CVI, S-CVI and Kappa (K) values all equal to a value of 1.00. Such an optimal score proves the topicality of all 14 items and high content validity, which proves the appropriateness of the implementation of the SmartJawi App.

Table 5. Summary of adjusted Kappa coefficient (K) and Scale-Level Content Validity Index (S-CVI)

Total of I-CVI	14	Total of S-CVI	14
Total I-CVI/Average: (Total I-CVI/Total Items)	1	Total I-CVI: (Total I-CVI/Total Item)	1

C. RQ3: Is There a Difference in Children's Learning Motivation Score Before and After Using the SmartJawi App?

Table 6 portrays the pre- and post-test scores for learning motivation among the nine participants. The results demonstrate beyond doubt that participants scored higher on the post-test than on the pre-test. Moreover, the increase ranged from 12 to 45 points, suggesting a perceptible rise in motivation levels following the integration of the application. This evidence supports the idea that intervention has a positive effect on participants' motivational states. It also exemplifies that the application is effective in promoting a stronger sense of enthusiasm and involvement in educational activity.

Table 7 presents the results of the normality tests for the learning motivation data, calculated using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The significance values for both tests were above 0.05 ($p = 0.200$ and $p = 0.735$, respectively). Hence, the data difference between the pre- and post-test scores is normally distributed. Therefore, the normality assumption required for parametric tests is met, allowing the use of paired-sample t-tests to analyze the differences in learning motivation before and after the intervention.

Table 6. Statistical analysis of the differences in learning motivation before and after the SmartJawi App intervention

Participant	Pre	Post	Difference
1	44	89	45
2	48	89	41
3	48	90	42
4	48	79	31
5	48	60	12
6	44	78	34
7	66	90	24
8	38	63	25
9	46	76	30

Table 7. Distribution characteristics and normality assumption tests for learning motivation data

Tests of Normality						
Score Difference	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
	0.151	9	0.200*	0.954	9	0.735

*: This is a lower bound of true significance.
a: Lilliefors Significance Correction

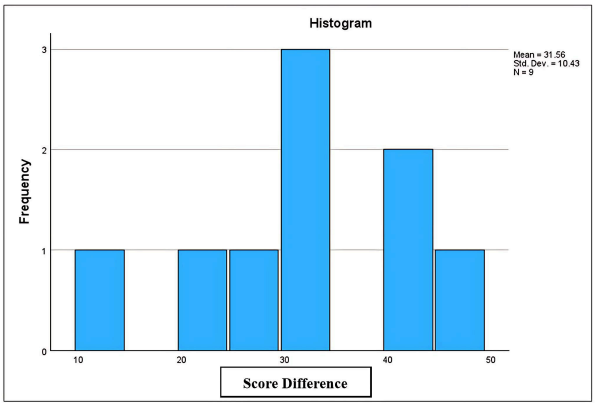

Fig. 3. Score Data distribution according to histogram.

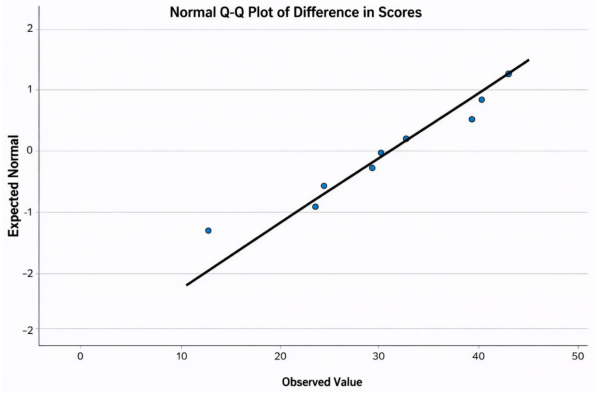

Fig. 4. QQ Plot for data normality test.

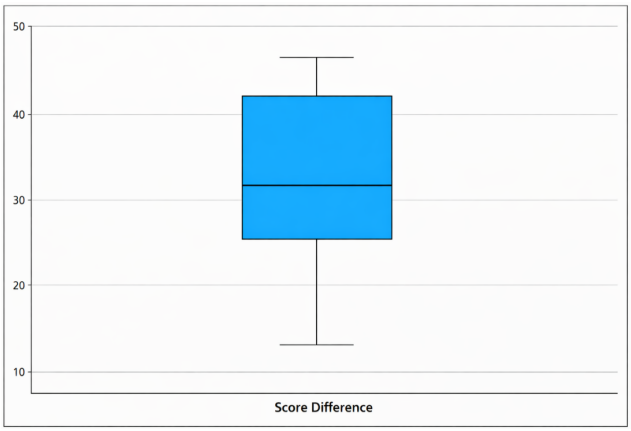

Fig. 5. Single-group pre- and post-test study design.

To satisfy the criteria of the parametric test, normal analysis of the difference in the learning motivation scores pre-intervention and after the intervention was conducted. As Fig. 3 and Fig. 4 always indicate, the data is normally distributed: the histogram shows a bell-shaped curve, which does not have any extreme values, and the data points on the Q-Q plot are clustered along the reference diagonal line. This finding justifies the suitability of using a paired-sample t-test in examining the variations in student motivation.

Fig. 5 presents the single-group pre-test and post-test research design employed in this study to measure learning motivation. It demonstrates that the same group of

participants was assessed twice, before and after the implementation of the learning application. Interestingly, this design enabled the researcher to assess changes in motivation levels directly attributable to the intervention.

The results in Table 8 revealed a significant difference between pre-test and post-test motivation scores after using the SmartJawi App. Paired t-test analysis yielded $t(8) = -9.08$, $p < 0.001$, indicating a statistically significant difference.

The mean difference of −31.56 reflects that the participants' motivation scores increased significantly after using the application. Meanwhile, the negative sign on the mean difference reveals that the comparison is based on the before-and-after order. It also demonstrates an increase in motivation scores from the pre-test to the post-test.

Table 8. Statistical significance of the mean differences in pre-test and post-test motivation scores

Pair	Comparison	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference		t	df	Sig.-One-tailed	Sig.-Two-tailed
					Lower	Upper				
1	Before-After SmartJawi App Used	−31.556	10.430	3.477	−39.573	−23.539	−9.077	8	< 0.001	< 0.001

The 95% confidence interval for the mean difference is between −39.57 and −23.54, excluding zero and suggesting that the observed increase in motivation is unlikely to be due to chance. The effect size was measured using Cohen's d, yielding a value of 3.03, which is a very large effect by Cohen's conventions ($d > 0.80$). Therefore, the use of the SmartJawi App is statistically and substantively significant in increasing participants' motivation to learn. Overall, the findings posit that the SmartJawi App has a statistically significant positive effect on learning motivation with practical significance.

V. Discussion

The main challenge in learning Jawi at the preschool level stems from children's difficulty in mastering Jawi letters [34]. This problem often results in reading and writing errors since children are still at an early stage of visual discrimination, which, in turn, marginalizes Jawi writing compared to Rumi writing [35]. Additionally, traditional methods that rely on structured one-on-one guidance are revealed to be time-consuming and highly dependent on the intensity of interaction between educators and children [36]. This conventional practice, which tends to be repetitive, is reported to be less effective at engaging children than digital approaches [37]. Additionally, the development of the SmartJawi App is a strategic solution that proposes integrating interactive animation features as a main function [38, 39]. This feature can provide dynamic visual support to strengthen children's ability to distinguish letter shapes [40], thereby reducing cognitive load and increasing motivation [41] for learning through more effective digital experiences. Correspondingly, it is the role of teachers to provide children with autonomy when engaging in technology-based activities, as greater autonomy increases internal motivation to continue learning [10, 11].

Based on expert assessment, the effectiveness of the language application also depends on a smooth, well-designed navigation system that ensures children can perform visual activities without interruption. Notably, expert consensus confirmed that SmartJawi App's navigation features meet the needs of early education [42]. Subsequently, analysis during the evaluation phase indicated a significant shift in child learning motivation, with the average score rising from moderate to high after the intervention [43]. This increase was driven by the more dynamic and fun nature of the application compared to traditional methods that rely solely on paper and pencil [44]. Critically, the use of technology tools such as SmartJawi App provides a more interactive, visually appealing learning experience and immediate feedback. These results confirm that integrating technology into modern pedagogy is more effective at stimulating child motivation than static conventional teaching methods [45]. In line with this, digital environments that support children's autonomy can significantly enhance a child's intrinsic motivation to learn and achieve success in the activities or tasks they undertake [46].

Finally, several limitations in this study cannot be avoided by researchers and must be addressed, especially for future researchers. In particular, the first limitation is the small sample size. The study's limited sample size limits the generalizability of its findings to a wider population, although it reflects the socio-cultural context of private kindergartens in Malaysia [32]. Second, the novelty effect on the use of digital technology may affect children's early developmental motivation and encourage their autonomy in performing activities well. In response, the researchers suggest that future studies adopt a longitudinal design and a larger sample to confirm the long-term effects of the SmartJawi App on children's motivation. In addition, future studies can also include a control group to compare the effectiveness of motivation between digital and traditional methods in more depth.

VI. Conclusion

The SmartJawi App is highly relevant to the field of early childhood education, as it can be viewed as an interactive tool that actively promotes young learners' interest in Jawi script, using a sound, engaging, and user-friendly approach. The application can keep children motivated by incorporating playful features that promote the acquisition of basic skills in a user-friendly, stimulating way, supporting the child's cognitive development. Simultaneously, this application serves as an introduction and offers Jawi orthography in aesthetically pleasing visual and audio formats, thus providing a multisensory learning experience. At the same time, it provides a fundamental foundation for early literacy by encouraging imaginative inquiry and creating a learning environment that is not overbearing. It also aligns with modern best practices in early childhood curriculum

development. In future studies, the SmartJawi App can be examined for its effectiveness in promoting children's intrinsic motivation, its ability to integrate gamification techniques into the pedagogical construct, and its role as an auxiliary tool in the preschool curriculum. Such an approach could stimulate their interest and positive attitudes towards learning Jawi from an early developmental phase.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Azam Ghazali: Conceptualization, Methodology, Data Curation, Formal Analysis, and Writing—Original Draft. Mohd Mahzan Awang: Supervision, Project Administration, Funding Acquisition, and Writing—Review & Editing. Zakiah Mohamad Ashari: Investigation, Validation, and Software. Joanne Hardman: Methodology and Writing—Review & Editing. Mazeni Ismail: Data Collection and Visualization. Haiza Hayati Baharudin: Resources and Technical Support. All authors have read and agreed to the published version of the manuscript.

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