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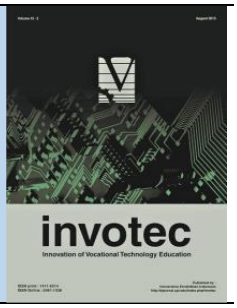

Hybrid Digital and Traditional Assessments within an Assessment-as-Learning Framework

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ABSTRACT

The increasing integration of digital technologies in higher education has transformed assessment practices and encouraged the adoption of Assessment-as-Learning (AaL), which emphasizes reflection, self-monitoring, and learner autonomy. Despite the growing popularity of digital assessment, empirical evidence comparing its effectiveness with traditional assessment in promoting student engagement remains limited. This study investigated whether digital and traditional assessment modalities produce different levels of cognitive engagement when implemented within an AaL framework. A quantitative counterbalanced repeated-measures design was employed involving 72 undergraduate students enrolled in an Educational Evaluation course at a public university in Indonesia. Participants completed both traditional and digital assessment activities addressing equivalent learning objectives. Cognitive engagement was measured using an adapted version of the Student Engagement Instrument (SEI) focusing on the Control and Relevance of School Work dimension. Descriptive statistics, Shapiro–Wilk tests and paired-samples t-tests were conducted using IBM SPSS Statistics 25. The results indicated high levels of cognitive engagement under both traditional ($M = 3.92$, $SD = 0.59$) and digital assessment conditions ($M = 3.76$, $SD = 0.64$). However, the difference was not statistically significant, $t(71) = 1.901$, $p = .061$, with a small effect size ($d = 0.22$). These findings suggest that assessment modality alone does not significantly influence cognitive engagement. Instead, pedagogical elements embedded within the AaL framework appear to play a more important role in supporting meaningful learning. The study provides empirical support for hybrid assessment models that combine digital and traditional approaches while maintaining a strong focus on reflective and learner-centered assessment design.

1. Introduction

The rapid development of digital technologies has substantially transformed teaching, learning, and assessment practices in higher education. Learning management systems, artificial intelligence (AI), learning analytics, digital portfolios, and online collaboration platforms are

increasingly embedded within educational ecosystems, creating new opportunities for more flexible, interactive, and data-informed assessment practices (Johar et al., 2023; Viberg et al., 2018). As a result, assessment is no longer viewed solely as a mechanism for measuring learning outcomes but also as an integral component of the learning process itself. This paradigm shift is reflected in the concept of Assessment as Learning (AaL), which emphasizes learners' active involvement in monitoring, evaluating, and regulating their own learning processes (Black & Wiliam, 1998; Earl, 2012). Within this framework, assessment functions not only as a source of evidence for instructors but also as a vehicle for developing metacognitive awareness, self-reflection, learner autonomy, and self-regulated learning (Boud & Molloy, 2013; Nicol & Macfarlane-Dick, 2006; Panadero et al., 2019).

The effectiveness of Assessment as Learning is closely associated with student engagement. Engagement has long been recognized as a multidimensional construct encompassing behavioral, emotional, and cognitive dimensions that collectively influence learning quality and academic achievement (Fredricks et al., 2004). Among these dimensions, cognitive engagement is particularly relevant to AaL because it reflects students' willingness to invest effort, apply learning strategies, monitor understanding, and actively participate in knowledge construction. Furthermore, cognitive engagement is strongly associated with self-regulation, persistence, and meaningful learning outcomes, making it a critical indicator of successful learning experiences (Appleton et al., 2006). Recent evidence also suggests that engagement remains one of the strongest predictors of learning success in technology-enhanced environments and is increasingly used as a key metric within learning analytics research (Bergdahl et al., 2024; Johar et al., 2023).

The growing adoption of digital technologies has stimulated considerable interest in understanding how digital assessment influences student engagement. Digital assessment environments provide opportunities for immediate feedback, multimodal interaction, adaptive assessment, and continuous monitoring of learning progress. Research has shown that learning analytics dashboards, self-assessment systems, and feedback-supported digital environments can positively influence students' engagement and self-regulated learning behaviors (Ifenthaler et al., 2023; Martinez et al., 2023; Ramaswami et al., 2023). Similarly, e-assessment practices have been reported to enhance students' cognitive engagement by facilitating more interactive and learner-centered assessment experiences (Laaziz et al., 2024). In addition, recent advances in AI-supported educational technologies have further expanded the possibilities for personalized feedback, adaptive learning pathways, and reflective learning activities, all of which align closely with the principles of Assessment as Learning (El Msayer et al., 2026; Zainuddin et al., 2026).

The emergence of generative artificial intelligence has intensified discussions regarding the future of assessment in higher education. Contemporary assessment practices are increasingly shifting from product-oriented evaluation toward authentic, process-oriented, and reflective assessment approaches that emphasize learner agency and evaluative judgment (Lim, 2024; Panadero et al., 2019). Recent studies indicate that formative assessment practices can empower students' agentive engagement by encouraging active participation in monitoring and directing their own learning processes (Mohammadi Zenouzagh et al., 2025). Likewise, systematic reviews have demonstrated that effective formative assessment implementation depends on meaningful feedback, student participation, and opportunities for reflection rather than merely on technological sophistication (Yan et al., 2021). These developments suggest that while digital technologies may support engagement, the pedagogical design of assessment activities remains a critical determinant of learning effectiveness.

Within vocational and technology-oriented education, digital technologies have become increasingly important for supporting learning and assessment. Firmansyah et al. (2021) found that e-learning implementation contributed positively to learning effectiveness in vocational education. Similarly, Pratiwi & Abdullah (2023) reported that students' preferences regarding teachers' use of digital technology positively influenced the development of vocational technical skills. Furthermore,

Karpin & Mahmudatussa'adah (2022) demonstrated that reflective learning activities support learner autonomy, a core principle of Assessment as Learning. More recently, Permana & Haritman (2024) emphasized that educational effectiveness depends not merely on technology adoption but on the appropriate design and integration of learning technologies within instructional contexts.

Despite these developments, an important research gap remains. Existing studies have primarily focused on digital learning environments, learning analytics, formative assessment, learner autonomy, and technology adoption. Comparatively limited attention has been given to examining whether digital assessments actually produce different levels of cognitive engagement than traditional assessments when both are intentionally designed within an Assessment-as-Learning framework. Moreover, the widespread assumption that digital assessment is inherently superior to traditional assessment has received limited empirical verification. Emerging evidence suggests that learner participation, self-regulation, feedback quality, and reflective learning opportunities may exert a stronger influence on engagement than the assessment medium itself (Bergdahl et al., 2024; Mohammadi Zenouzagh et al., 2025; Yan et al., 2021).

Therefore, this study investigates differences in students' cognitive engagement between digital and traditional assessment modalities implemented within an Assessment-as-Learning framework. Using a counterbalanced repeated-measures design involving undergraduate students enrolled in an Educational Evaluation course, this study seeks to determine whether assessment modality significantly influences cognitive engagement. The findings are expected to contribute to the growing literature on Assessment as Learning by providing empirical evidence regarding the role of assessment modality in supporting student engagement and informing the design of balanced assessment ecosystems in vocational higher education.

2. Methods

2.1 Research Design and Participants

This study employed a quantitative repeated-measures design to compare students' cognitive engagement across traditional and digital assessment modalities within an Assessment-as-Learning (AaL) framework. A repeated-measures approach was selected because it allows the same participants to experience both assessment conditions, thereby reducing individual variability and increasing statistical sensitivity when examining differences in engagement between assessment modalities. Such within-subject designs are particularly appropriate when investigating changes in engagement resulting from different instructional or assessment interventions because engagement is influenced by individual learner characteristics and contextual factors (Appleton et al., 2006; Fredricks et al., 2004).

The study was conducted in two consecutive assessment sessions within the Educational Evaluation course. In the first session, students completed a traditional assessment task, whereas in the second session they completed an equivalent digital assessment task. Both assessment activities addressed the same learning objectives and course content to ensure comparability between conditions. The counterbalanced structure was implemented to minimize potential order effects and strengthen internal validity.

Table 1. Counterbalanced Repeated-Measures Design

Sequence	Session 1	Session 2
Group A (n = 36)	Traditional Assessment	Digital Assessment
Group B (n = 36)	Digital Assessment	Traditional Assessment

The participants consisted of 72 undergraduate students enrolled in the Information Systems and Technology Education Program at a public university in Purwakarta, Indonesia. Because all students registered in the coSurse participated in the study, total sampling was employed. The use

of a repeated-measures design was considered appropriate because student engagement is influenced by individual learner characteristics, and within-subject comparisons provide greater statistical efficiency than comparisons involving separate participant groups. Prior to data collection, participants were informed about the purpose of the study and provided informed consent. Participation was voluntary, and all responses were anonymized to ensure confidentiality and ethical compliance throughout the research process.

2.2 Instruments and Procedures

Data were collected using an adapted version of the Student Engagement Instrument (SEI) developed by Appleton et al. (2006). The SEI has been widely used to assess students' cognitive and psychological engagement in educational settings and has demonstrated strong psychometric properties across diverse educational contexts. Consistent with contemporary engagement research emphasizing the importance of cognitive engagement as a predictor of meaningful learning, self-regulation, and academic success, this study focused specifically on the Control and Relevance of School Work dimension (Appleton et al., 2006; Bergdahl et al., 2024).

This dimension was selected because it aligns closely with the principles of Assessment-as-Learning (AaL), particularly learner autonomy, self-monitoring, reflection, and perceived relevance of learning activities (Earl, 2012; Nicol & Macfarlane-Dick, 2006; Panadero et al., 2019). The adapted instrument consisted of eight items measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The complete list of the original Student Engagement Instrument (SEI) items developed by Appleton et al. (2006), together with the subset of items adapted for this study, is provided in Appendix A. The items assessed students' perceptions of task relevance, assessment fairness, self-monitoring behaviors, perceived learning benefits, and effort-related beliefs regarding academic performance.

To establish content validity, the instrument was reviewed by two experts in educational assessment and educational technology. Their feedback was used to refine item wording and ensure the relevance, clarity, and suitability of the instrument for the higher education context. Internal consistency reliability was subsequently evaluated using Cronbach's alpha coefficient. The analysis yielded a Cronbach's alpha value of .815, indicating good reliability and suggesting that the instrument consistently measured students' cognitive engagement across assessment conditions.

Data collection was conducted over two assessment sessions covering equivalent instructional content within the Educational Evaluation course. During the traditional assessment session, students completed handwritten reflective tasks and concept-mapping activities designed to encourage metacognitive reflection, self-evaluation, and knowledge consolidation. During the digital assessment session, students completed equivalent learning tasks using digital technologies, including Canva, AI-assisted learning applications, and online submission platforms. The inclusion of reflective activities across both conditions was intended to preserve the core principles of Assessment-as-Learning, which emphasize learner agency, evaluative judgement, and self-regulated learning (Boud & Molloy, 2013; Panadero et al., 2019; van der Linden et al., 2023).

To ensure comparability between assessment modalities, the learning objectives, assessment criteria, instructional duration, and task complexity were maintained across both conditions. Following the completion of each assessment session, participants responded to the cognitive engagement questionnaire based on their experiences with the corresponding assessment modality.

2.3 Data Analysis

Data analysis was performed using IBM SPSS Statistics Version 25. Descriptive statistics, including means, standard deviations, minimum values, and maximum values, were calculated to summarize students' cognitive engagement under both traditional and digital assessment conditions.

Prior to inferential analysis, the normality assumption was evaluated using the Shapiro–Wilk test. This test was selected because it is appropriate for assessing normality in relatively small to moderate sample sizes and is widely recommended for educational and behavioral research involving repeated-measures data. The results indicated that engagement scores under both assessment conditions were normally distributed ($p > .05$).

Because the same participants experienced both assessment modalities and the normality assumption was satisfied, a paired-samples t-test was employed to examine whether significant differences existed in cognitive engagement between traditional and digital assessment conditions. The paired-samples t-test is appropriate for comparing the means of two related conditions measured from the same participants and has been frequently applied in educational intervention studies investigating learner engagement and assessment outcomes (Ifenthaler et al., 2023; Laaziz et al., 2024).

Statistical significance was evaluated at the .05 level. To complement significance testing, effect size was calculated using Cohen's d, which provides information regarding the practical magnitude of observed differences beyond statistical significance. Following Cohen's conventional interpretation, effect sizes of $d = .20$, $d = .50$, and $d = .80$ were interpreted as small, medium, and large effects, respectively.

3. Result and Discussion

3.1 Descriptive Analysis of Cognitive Engagement

Prior to examining differences between assessment modalities, the reliability of the cognitive engagement instrument was evaluated. The results demonstrated good internal consistency, with a Cronbach's Alpha coefficient of .815 across the eight questionnaire items. This value exceeded the commonly accepted threshold of .70, indicating that the instrument was sufficiently reliable for measuring students' cognitive engagement throughout the study.

The descriptive analysis revealed consistently high levels of cognitive engagement across both assessment modalities. Students generally reported positive perceptions regarding the relevance, usefulness, and reflective value of the assessment activities implemented within the Assessment-as-Learning (AaL) framework. Across all indicators, responses were predominantly concentrated within the Agree (4) and Strongly Agree (5) categories, indicating that both assessment approaches successfully encouraged students to monitor their understanding, reflect on their learning progress, and perceive assessment activities as meaningful components of the learning process.

Under the traditional assessment condition, students completed handwritten reflective assignments and concept-mapping activities. To illustrate the distribution of responses across the eight cognitive engagement indicators, Table 2 summarizes the frequency of responses for each Likert-scale category.

Table 2. Distribution of Student Responses under Traditional Assessment Conditions

Item	SD (1)	D (2)	N (3)	A (4)	SA (5)
P1	0	5	19	33	15
P2	1	9	13	34	15
P3	0	1	9	27	35
P4	0	5	20	33	14
P5	1	1	10	25	35
P6	2	7	15	30	18
P7	0	7	21	31	13
P8	0	6	12	31	23

As shown in Table 2, responses were heavily distributed toward the upper end of the scale, particularly for items associated with learning relevance, self-evaluation, and perceived usefulness of assessment activities. The dominance of Agree and Strongly Agree responses suggests that conventional assessment practices can effectively support reflective learning when assessment tasks are explicitly aligned with instructional objectives.

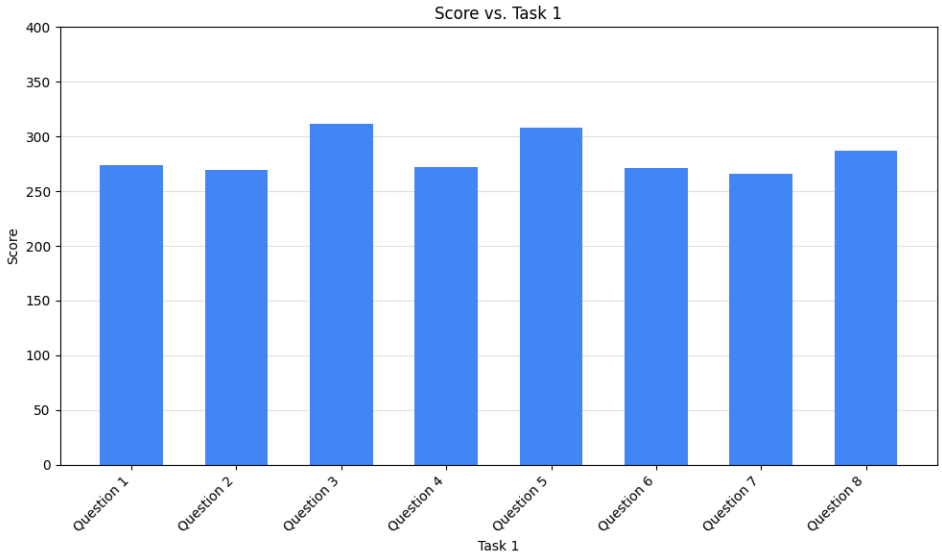


Figure 1. Distribution of Cognitive Engagement Responses under Traditional Assessment Conditions.

As illustrated in Figure 1, only a small proportion of students selected Disagree or Strongly Disagree options, indicating generally favorable perceptions toward traditional assessment activities. A similar pattern emerged during the digital assessment condition. Students completed equivalent assessment tasks using digital tools, including Canva, AI-assisted learning applications, and online submission platforms. Table 3 presents the frequency distribution of responses for the digital assessment condition.

Table 3. Distribution of Student Responses under Digital Assessment Conditions

Item	SD (1)	D (2)	N (3)	A (4)	SA (5)
P1	0	1	20	36	15
P2	0	1	17	39	15
P3	0	5	12	30	25
P4	0	1	23	33	15

Item	SD (1)	D (2)	N (3)	A (4)	SA (5)
P5	0	5	11	30	26
P6	1	13	8	29	21
P7	0	8	20	30	14
P8	1	0	15	35	21

The descriptive findings indicate that digital assessment activities were positively perceived by students and successfully supported engagement throughout the learning process. Although several items demonstrated relatively high frequencies within the Strongly Agree category, the overall response pattern remained highly comparable to that observed under traditional assessment conditions. Figure 2 provides a visual representation of the response distribution under the digital assessment condition.

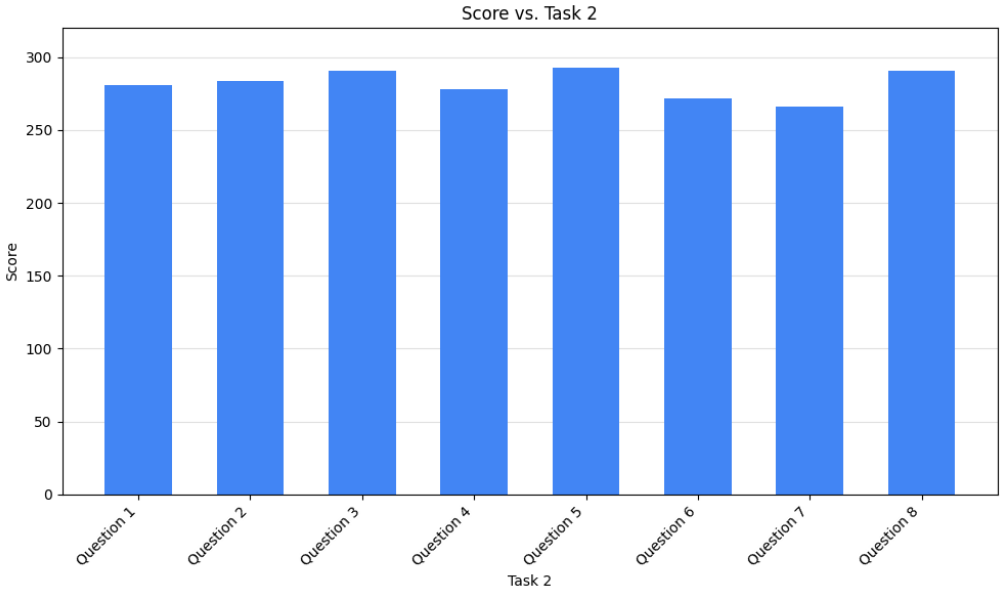


Figure 2. Distribution of Cognitive Engagement Responses under Digital Assessment Conditions

Consistent with the traditional condition, Figure 2 demonstrates that students generally evaluated digital assessment experiences positively. Most responses remained concentrated in the upper end of the response scale, suggesting that digital assessment activities were perceived as meaningful and supportive of learning. To provide an overall comparison between the two assessment modalities, descriptive statistics for the composite engagement scores are presented in Table 4.

Table 4. Descriptive Statistics of Cognitive Engagement Scores

Assessment Modality	Mean	SD	Minimum	Maximum
Traditional Assessment	3.92	0.59	2.00	4.88
Digital Assessment	3.76	0.64	2.25	5.00

As indicated in Table 4, cognitive engagement remained relatively high under both assessment conditions. Mean scores approached the upper range of the five-point scale, suggesting that students generally experienced positive engagement regardless of whether assessment activities were conducted through traditional or digital formats. Although the traditional assessment

condition produced a slightly higher mean score than the digital assessment condition, the difference appeared modest at the descriptive level.

3.2 Comparative Analysis

Before conducting inferential testing, the normality assumption was examined using the Shapiro–Wilk test. The results indicated that both traditional assessment scores (W = .969, p = .074) and digital assessment scores (W = .982, p = .402) were normally distributed. Because both distributions satisfied the normality assumption (p > .05), a paired-samples t-test was employed to compare cognitive engagement across the two assessment modalities. The results of the paired-samples t-test are presented in Table 5.

Table 5. Paired-Samples t-Test Results

Variable	Mean	SD	t	df	p-value	Cohen's d
Traditional Assessment	3.92	0.59				
Digital Assessment	3.76	0.64	1.901	71	.061	0.22

The paired-samples t-test revealed no statistically significant difference in cognitive engagement between traditional assessment (M = 3.92, SD = 0.59) and digital assessment (M = 3.76, SD = 0.64), t(71) = 1.901, p = .061. Although students reported slightly higher engagement during traditional assessment activities, the observed difference did not reach statistical significance.

Furthermore, the calculated effect size was small (Cohen’s d = 0.22), indicating a negligible practical difference between the two assessment modalities. These findings suggest that students maintained relatively similar levels of cognitive engagement regardless of whether assessment tasks were completed through conventional handwritten activities or technology-enhanced digital platforms.

3.3 Discussion

The present study investigated whether traditional and digital assessment modalities produce different levels of cognitive engagement when implemented within an Assessment-as-Learning framework. Contrary to the widespread assumption that digital technologies automatically enhance student engagement, the findings revealed no statistically significant difference between the two assessment modalities.

This finding reinforces the fundamental principles of Assessment-as-Learning, which emphasize reflection, self-monitoring, metacognition, and learner agency as the primary mechanisms through which assessment contributes to learning (Black & Wiliam, 1998; Earl, 2012). Across both conditions, students were required to evaluate their understanding, reflect on their performance, and monitor their learning progress. Consequently, the reflective structure embedded within the assessment activities may have exerted a stronger influence on cognitive engagement than the technological characteristics of the assessment medium itself.

The findings are also consistent with contemporary research highlighting that meaningful engagement emerges primarily through active participation, self-regulation, and cognitively demanding learning experiences rather than through technology use alone. Bergdahl et al. (2024), in their systematic review of student engagement in higher education learning analytics, concluded that engagement is strongly influenced by pedagogical design and learning processes rather than technological infrastructure itself. Similarly, Johar et al. (2023) emphasized that learning analytics and digital technologies improve engagement only when they are integrated into meaningful instructional and assessment strategies.

The absence of a significant difference between assessment modalities may be explained by the substantial equivalence of the learning tasks implemented across both conditions. Although

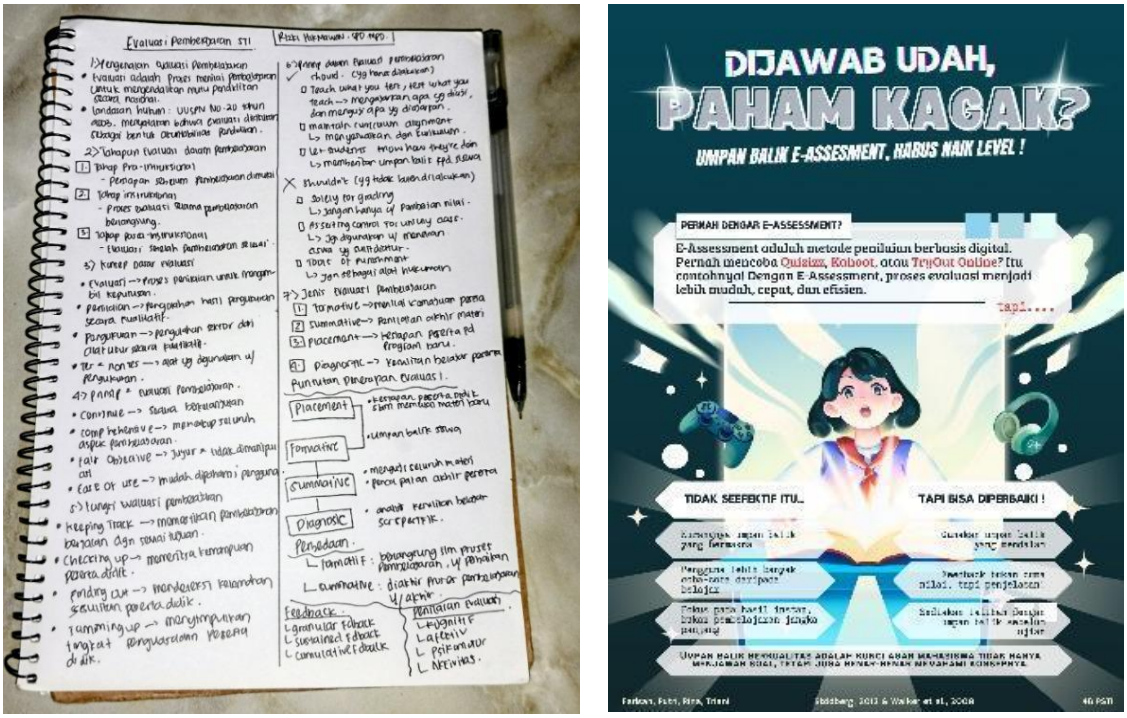
different media were employed, the learning objectives, assessment criteria, expected outcomes, and reflective processes remained consistent. Therefore, students encountered comparable cognitive demands regardless of whether they completed handwritten reflective activities or technology-supported digital tasks. This interpretation aligns with research on formative assessment and self-regulated learning, which suggests that opportunities for reflection and evaluative judgement are more influential than delivery format in shaping learner engagement (Nicol & Macfarlane-Dick, 2006; Panadero et al., 2019).

The findings further support recent evidence demonstrating that formative assessment practices can foster engagement when learners are actively involved in monitoring and regulating their learning processes. van der Linden et al. (2023) found that alignment between assessment practices and self-regulated learning principles plays a critical role in supporting meaningful engagement. Likewise, Ifenthaler et al. (2023) reported that self-assessment activities supported by learning analytics can enhance students' awareness of their learning processes, regardless of the specific technological platform employed.

Another plausible explanation concerns participant characteristics. The respondents were undergraduate students enrolled in an Information Systems and Technology Education program and therefore possessed relatively high levels of digital literacy. As digital technologies are already embedded in their daily academic experiences, digital assessments may no longer represent a novel learning experience capable of substantially increasing engagement. This interpretation aligns with contemporary learning analytics literature suggesting that the educational value of technology depends largely on how it is pedagogically integrated rather than on the technology itself (Bergdahl et al., 2024; Viberg et al., 2018).

Importantly, the findings should not be interpreted as evidence that digital assessment lacks educational value. Previous studies have reported several advantages of digital assessment, including increased flexibility, immediate feedback, multimodal representation, and data-informed support for learning (Laaziz et al., 2024; Martinez et al., 2023; Zainuddin et al., 2026). However, the present findings indicate that these advantages do not automatically translate into higher cognitive engagement when equivalent reflective learning opportunities are already embedded within traditional assessment activities.

From a practical perspective, the results support the implementation of hybrid assessment ecosystems that strategically combine traditional and digital approaches. Rather than prioritizing a specific assessment medium, educators should focus on designing assessment activities that promote reflection, learner autonomy, evaluative judgement, and self-regulation. These pedagogical characteristics represent the essence of Assessment-as-Learning and appear capable of sustaining high levels of cognitive engagement across both traditional and digital learning environments (Boud & Molloy, 2013; Mohammadi Zenouzagh et al., 2025; Panadero et al., 2019).



First Task *First Task*

Figure 3. Representative student artifacts generated during traditional and digital assessment activities within the Assessment-as-Learning framework. (Left: handwritten reflective notes and concept maps; Right: Canva-based digital infographic assignments developed using AI-assisted tools.)

4. Conclusion

This study investigated whether traditional and digital assessment modalities produce different levels of students' cognitive engagement when implemented within an Assessment-as-Learning (AaL) framework. The findings indicate that both assessment modalities are equally capable of fostering meaningful cognitive engagement when they are intentionally designed to promote reflection, self-monitoring, learner autonomy, and metacognitive regulation. Rather than the assessment medium itself, the pedagogical design underlying assessment activities appears to play a more influential role in supporting students' engagement. These findings reinforce the central principles of Assessment-as-Learning by demonstrating that meaningful learning can be achieved through both traditional and digital assessment environments when reflective learning opportunities are consistently embedded. Consequently, educators should prioritize the design of learner-centered and reflective assessment practices while strategically integrating traditional and digital approaches to create balanced assessment ecosystems. Although the study was conducted within a single undergraduate program and focused solely on cognitive engagement, it provides empirical evidence that contributes to the growing discourse on hybrid assessment in higher education. Future research should examine broader educational contexts, additional dimensions of student engagement, and the potential contributions of emerging technologies, including artificial intelligence, adaptive feedback, learning analytics, and gamification, in strengthening Assessment-as-Learning practices..

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

References

Appleton, J. J., Christenson, S. L., Kim, D., & Reschly, A. L. (2006). Measuring cognitive and psychological engagement: Validation of the Student Engagement Instrument. *Journal of School Psychology*, *44*(5), 427–445.

Bergdahl, N., Bond, M., Sjöberg, J., Dougherty, M., & Oxley, E. (2024). Unpacking student engagement in higher education learning analytics: a systematic review. *International Journal of Educational Technology in Higher Education*, *21*(1), 63.

Black, P., & Wiliam, D. (1998). Assessment and Classroom Learning. *Assessment in Education: Principles, Policy & Practice*, *5*(1), 7–74.

Boud, D., & Molloy, E. (2013). Rethinking models of feedback for learning: the challenge of design. *Assessment & Evaluation in Higher Education*, *38*(6), 698–712.

Earl, L. M. (2012). *Assessment as learning: Using classroom assessment to maximize student learning*. Corwin press.

El Msayer, M., Bouihi, B., Bousselham, A., Aoula, E., & Deraoui, A. (2026). Designing Formative Adaptive Assessment for Engineering Education: Integrating Computerized Adaptive Testing and Competency-Based Diagnostic Modelling. *International Journal of Engineering Pedagogy (IJEP)*, *16*(1), 133–154.

Firmansyah, A., Samsudin, A. F., Aqmal, R. Y., Sasmita, A. H., & Dwiyanti, V. (2021). E-learning methods impact in vocational education. *INVOTEC*, *17*(1), 14-21.

Fredricks, Jennifer A, Blumenfeld, Phyllis C, & Paris, Alison H. (2004). School Engagement: Potential of the Concept, State of the Evidence. *Review of Educational Research*, *74*(1), 59–109.

Ifenthaler, D., Schumacher, C., & Kuzilek, J. (2023). Investigating students' use of self-assessments in higher education using learning analytics. *Journal of Computer Assisted Learning*, *39*(1), 255–268.

Johar, N. A., Kew, S. N., Tasir, Z., & Koh, E. (2023). Learning analytics on student engagement to enhance students' learning performance: A systematic review. *Sustainability*, *15*(10), 7849.

Laaziz, Y., Chemsi, G., & Radid, M. (2024). The Influence of E-Assessment on Students' Cognitive Engagement in Higher Education. *International Journal of Engineering Pedagogy (IJEP)*, *14*(4), 54–67.

Lim, K. (2024). Assessing beyond grades: unravelling the implications on student learning and engagement in higher education. *Assessment & Evaluation in Higher Education*, *49*(5), 665–679.

Karpin, K., & Mahmudatussa'adah, A. (2022). Learning Reflections to Build Learner Autonomy. *INVOTEC*, *18*(1), 32-40.

Martinez, C., Serra, R., Sundaramoorthy, P., Booij, T., Vertegaal, C., Bounik, Z., van Hastenberg, K., & Bentum, M. (2023). Content-Focused Formative Feedback Combining Achievement, Qualitative and Learning Analytics Data. *Education Sciences*, *13*(10).

Mohammadi Zenouzagh, Z., Admiraal, W., & Saab, N. (2025). Empowering students' agentive engagement through formative assessment in online learning environment. *International Journal of Educational Technology in Higher Education*, *22*(1), 9.

Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: a model and seven principles of good feedback practice. *Studies in Higher Education*, *31*(2), 199–218.

Panadero, E., Broadbent, J., Boud, D., & Lodge, J. M. (2019). Using formative assessment to influence self- and co-regulated learning: the role of evaluative judgement. *European Journal of Psychology of Education*, *34*(3), 535–557.

Permana, H., & Haritman, E. (2024). Determining priority criteria for using online learning media in Emergency Remote Teaching (ERT) using the Analytical Hierarchy Process (AHP) method. *INVOTEC*, *20*(1), 58-66.

Pratiwi, A. I., Abdullah, A. G., & Mukhidin, M. (2023). Unlocking the potential of vocational skills: How vocational high school students' preferences for teachers' use of digital technology influence telecommunication technical skills. *INVOTEC*, *19*(2), 135-143.

Ramaswami, G., Susnjak, T., & Mathrani, A. (2023). Effectiveness of a Learning Analytics Dashboard for Increasing Student Engagement Levels. *Journal of Learning Analytics*, *10*(3), 115–134.

van der Linden, J., van der Vleuten, C., Nieuwenhuis, L., & van Schilt-Mol, T. (2023). Formative Use of Assessment to Foster Self-Regulated Learning: the Alignment of Teachers' Conceptions and Classroom Assessment Practices. *Journal of Formative Design in Learning*, *7*(2), 195–207.

Viberg, O., Hatakka, M., Bälter, O., & Mavroudi, A. (2018). The current landscape of learning analytics in higher education. *Computers in Human Behavior*, *89*, 98–110.

Yan, Z., Li, Z., Panadero, E., Yang, M., Yang, L., & Lao, H. (2021). A systematic review on factors influencing teachers' intentions and implementations regarding formative assessment. *Assessment in Education: Principles, Policy & Practice*, *28*(3), 228–260.

Zainuddin, A., Wasis, Ekohariadi, Anistyarsari, Y., Rijanto, T., & Habibi. (2026). A systematic review of digital assessment trends in education from 2015-2025. *Multidisciplinary Reviews*, *9*(9), 2026433.

Appendix A. Original Student Engagement Instrument (Appleton)

No	***Cognitive Engagement***	***Item Text***
1	*Control and Relevance*	*The tests in my classes do a good job of measuring what I'm able to do.*
2	*Control and Relevance*	*Most of what is important to know you learn in school.*
3	*Control and Relevance*	*The grades in my classes do a good job of measuring what I'm able to do.*
4	*Control and Relevance*	*What I'm learning in my classes will be important in my future.*
5	*Control and Relevance*	*After finishing my schoolwork I check it over to see if it's correct.*
6	*Control and Relevance*	*When I do schoolwork I check to see whether I understand what I'm doing.*
7	*Control and Relevance*	*Learning is fun because I get better at something.*
8	*Control and Relevance*	*When I do well in school it's because I work hard.*

No	Cognitive Engagement	Item Text
9	Control and Relevance	I feel like I have a say about what happens to me at school.
10	Future Aspirations and Goals	I plan to continue my education following high school.
11	Future Aspirations and Goals	Going to school after high school is important.
12	Future Aspirations and Goals	School is important for achieving my future goals.
13	Future Aspirations and Goals	My education will create many future opportunities for me.
14	Future Aspirations and Goals	I am hopeful about my future.
15	Extrinsic Motivation	I'll learn, but only if my family/guardian(s) give me a reward. (Reversed)
16	Extrinsic Motivation	I'll learn, but only if the teacher gives me a reward. (Reversed)

Only items 1–8 (Control and Relevance of School Work dimension) were adapted and used in this study.