

Developing a Digital Handout for Assessment in Science Course: An ADDIE Model Approach

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ABSTRACT

Assessment literacy is a fundamental competency for preservice teachers, yet the Assessment in Science course still lacked structured learning materials that could support both classroom learning and independent study. This study aimed to develop a digital handout for the course and examine its practicality based on students' evaluations. This study employed a Research and Development design using the ADDIE model, which involved the phases of Analysis, Design, Development, Implementation, and Evaluation. Participants included 28 undergraduate science education students as target users, three students for readability testing, and one science education and assessment expert for qualitative validation. Data were collected through questionnaires consisting of Likert scale items and open-ended questions. The data were further analyzed using descriptive statistics and thematic analysis. The development process produced a digital handout containing learning objectives, concise theoretical explanations, practical examples, summaries, self-assessment questions, and interactive multimedia elements such as hyperlinks and QR codes. The practicality evaluation showed that the handout was rated practical overall ($M = 4.17$; $SD = 0.82$), with its strongest contributions in supporting concept understanding, classroom learning, and future review, although improvements are still needed in visual quality and layout spacing. In conclusion, the digital handout can be a practical learning resource for the Assessment in Science course. The findings imply that systematically developed digital materials can support assessment literacy in preservice science teacher education.

Keywords: ADDIE model, assessment literacy, digital handout, preservice science teacher, science teacher education

Introduction

Assessment literacy can be described as an educator's understanding of the basic principles of assessment practice, including what is assessed, why it is assessed, how it is assessed, potential problems with the assessment, and how to prevent them (Popham, 2011; Stiggins, 2002). Given its significant role in effective teaching, assessment literacy has become a fundamental competency to develop in teacher education programs (DeLuca, 2016; Konadu, 2025; Scarino, 2013). Moreover, DeLuca et al. (2016) emphasized that assessment literacy is a core professional requirement across educational systems; therefore, supporting teachers' assessment literacy has become a primary focus over the past two decades. Training in assessment literacy during preservice teacher education can significantly impact the quality of assessment practices throughout their teaching careers (Popham, 2011). For preservice science teachers, developing assessment competence is also important, as they must master not only content knowledge but also the skills to evaluate diverse aspects of scientific understanding,

from conceptual knowledge to inquiry-based processes and scientific reasoning (Siegel & Wissehr, 2011). The Assessment in Science course in the undergraduate science education program at Universitas Pendidikan Indonesia, therefore, serves as a foundational subject where preservice science teachers acquire essential skills in planning, developing, and implementing various assessment instruments that will support both their future teaching practices and research works, particularly in designing valid and reliable instruments for undergraduate thesis projects.

The effectiveness of any course depends on the quality and accessibility of its learning resources (Odunlade, 2017). As structured teaching materials, handouts play an important role in supporting students' learning by providing organised and comprehensive content that students can refer to during and after class sessions (Khotimah & Hastuti, 2021). According to Prastowo (2011), handouts are concise, literature-supported learning materials provided to students as practical instructional resources. Unlike transient lecture presentations, handouts have multiple functions. Besides helping students to grasp the most important concepts (Sumarni & Badruzsaufari, 2020), they provide scaffolding for independent learning and offer permanent references that students can revisit when preparing for assessments or conducting research (Sohail et al., 2024). Prastowo (2011) further explained that handouts help students to avoid excessive note-taking, serve as companions to instructor explanations, act as reference materials, remind students of key points, provide self-directed feedback through embedded exercises that allow students to check their own understanding, and assess learning outcomes.

The digital transformation of educational materials has offered opportunities for enhancing students' learning experiences. Digital learning materials provide enhanced accessibility, allowing students to access content from various devices at any time and location, thereby supporting flexible learning schedules that fit the context of higher education (Cserkó et al., 2024; Huong et al., 2026; Mayer, 2021). Beyond convenience, digital formats enable the integration of multimedia elements, such as videos, interactive examples, and hyperlinked resources that support deeper understanding through multiple modes of representation (Rzyankina, 2024). According to Mayer (2021), people learn more effectively when information is presented through both visual and verbal channels, as this dual-channel processing enhances comprehension and retention. Digital handouts also offer practical advantages such as easy updating to incorporate current research, searchability for quick information retrieval, and the ability to embed interactive elements that promote active engagement with content (Puchkova et al., 2021).

Despite the importance of comprehensive learning materials in higher education, there is a gap in the literature on the development of structured digital learning materials specifically designed for assessment literacy courses in pre-service science teacher education. While prior studies have examined digital learning materials in general higher education contexts (Cserkó et al., 2024; Puchkova et al., 2021) and the development of handouts in science education (Khotimah & Hastuti, 2021), none have specifically addressed the development of digital handouts for science assessment literacy. This is an important issue to address, given that assessment literacy covers both declarative and procedural knowledge (Dehqan & Sorkhi, 2020). This requires learning materials that go beyond general academic texts and provide contextualised, discipline-specific guidance. A preliminary evaluation of the Assessment in

Science course at Universitas Pendidikan Indonesia further revealed that students rated learning resources as the weakest aspect of the course. Currently, the course primarily relies on student-created PowerPoint presentations that lack depth, comprehensiveness and consistency. Although lecturers provide supplementary references such as e-books and journal articles, students often do not engage deeply with these materials and instead seek less credible online sources. The combination of this broader literature gap and a specific contextual need, therefore, highlights the importance of creating a structured digital handout for this course.

This research seeks to address the learning resource gap in the Assessment in Science course by developing a digital handout that supports both classroom learning and independent study. This research aims to provide students with accessible and structured learning materials that facilitate a deeper understanding of assessment principles. Based on this background, this study was guided by the following two research questions:

1. How is the digital handout for the Assessment in Science course developed using the ADDIE model?
2. What is the practicality of the digital handout for the Assessment in Science course based on students' evaluation?

Methods

Research design and procedure

This study employed a research and development (R&D) approach to systematically produce and validate an educational product. In this case, the product was a digital handout for the Assessment in Science course. Within this R&D framework, the development process followed the ADDIE instructional design model, consisting of five phases: Analysis, Design, Development, Implementation, and Evaluation (Branch & Varank, 2009). The ADDIE model was chosen because it provides a comprehensive and iterative framework for creating effective instructional materials, including handouts. Furthermore, in the revised framework, the ADDIE model embeds the evaluation phase at each stage to ensure continuous improvement and quality assurance, rather than serving as a single final step. As illustrated in Figure 1, evaluation is a central phase that informs decision-making throughout the development process, enabling refinement at each stage.

To address the above-mentioned research questions, this study progressed through each ADDIE phase and collected qualitative and quantitative data to inform decisions about handout development and to evaluate the final product. The development of the digital handout for the Assessment in Science course, following the ADDIE model, is described as follows.

First, the Analysis phase focused on identifying development needs, understanding the target audience, and determining content requirements. A preliminary course evaluation was conducted using questionnaires distributed to students from the 2022 batch who had completed the Assessment in Science course, assessing learning resources, teaching methods, and satisfaction. Semi-structured interviews with the lecturer also explored current teaching practices and perceived resource gaps. The characteristics of the target users (batch 2023 students) were examined through surveys and informal discussions, including their prior knowledge, digital literacy, learning preferences, and access to technology. Furthermore, document analysis of existing materials, including PowerPoint presentations and the course

syllabus (RPS), and a review of relevant literature on science education (e.g., textbooks and journals) were conducted to identify key learning needs and content coverage.

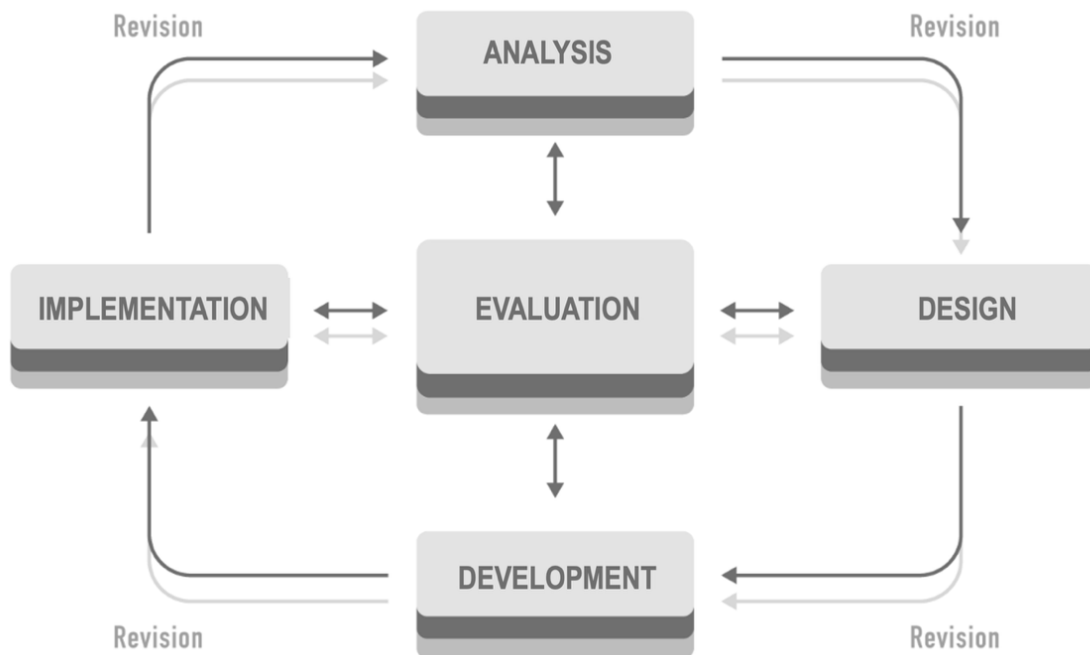


Figure 1. ADDIE's model

Second, in the *Design* phase, the researchers created a blueprint for the digital handout. This phase involved four key activities. First, instructional strategies were determined to balance theoretical explanations with practical examples. Second, the handout framework was developed so that each chapter included learning objectives, main content, practical examples, summaries, and self-assessment questions. Third, the visual layout was planned, specifying fonts, color schemes, and page layouts. Finally, multimedia elements were selected, including diagrams, sample assessments, and video demonstrations.

Third, the *Development* phase involved creating of the digital handout based on the blueprint. The draft handout underwent qualitative expert validation by one faculty member specializing in science education and assessment, who reviewed content accuracy, comprehensiveness, alignment with learning objectives, and appropriateness for the target audience. In terms of readability testing, three students from cohort 2022 who had previously completed the Science Assessment course were purposely selected based on the following two criteria: (1) achieving a grade of A in the Assessment in Science course, which indicates strong familiarity with the subject matter, and (2) achieving a grade of A in the English course, which ensures adequate English language proficiency to evaluate the handout's linguistic clarity. This aligns with the one-to-one formative evaluation approach recommended by Dick et al. (2015), in which a small number of individuals with specific characteristics are engaged to provide qualitative feedback on instructional materials prior to broader implementation. Furthermore, based on both expert judgment and student feedback, revisions were made to the handouts.

Fourth, in the *Implementation* stage, the researchers introduced the digital handout to the actual users in an authentic learning context, namely, the Assessment in Science classroom. The implementation involved using the digital handout in the Assessment in Science course for all undergraduate science education students from batch 2023 as the target users.

Finally, the *Evaluation* phase consisted of a summative evaluation of the digital handout product. Students who had used the digital handout completed a practicality questionnaire designed to evaluate various dimensions of the handout's quality and usability. The practicality instrument included both quantitative and qualitative items.

Participants

This research was conducted in the Science Education Study Program at Universitas Pendidikan Indonesia. The participants in this study comprised 28 undergraduate students (batch 2023) enrolled in the Assessment in Science course, who served as the target users of the digital handout. These 28 students participated specifically in the analysis, implementation, and evaluation phases. In addition, three science education students (batch 2022) and one expert in science education and assessment participated in the development phase, particularly in the readability test and expert judgment, respectively.

Data collection and analysis

This study collected qualitative and quantitative data across the development phases. During the Analysis phase, a needs assessment questionnaire was administered to batch 2023 students and included quantitative items (satisfaction, material adequacy, handout importance, and ideal page length) as well as qualitative items (preferred components, usage plans, interactive element preferences, and additional suggestions). During the Development phase, qualitative expert validation feedback was obtained from an expert in science education and assessment, supplemented by readability testing with three batch 2022 students. During the evaluation phase, a practicality questionnaire containing seven Likert-scale items and three open-ended questions was administered to Batch 2023 students. Prior to being administered to students, the questionnaire was qualitatively reviewed by an expert in science education and assessment. The researcher then revised the questionnaire based on this review. Quantitative data of students' evaluation were analyzed using descriptive statistics, while qualitative data were analyzed thematically to identify patterns and inform revisions.

Results and Discussion

Development of Digital Handout Using the ADDIE Model

The first research question examined how the digital handout was developed using the ADDIE model, which consists of five systematic phases: Analysis, Design, Development, Implementation, and Evaluation. This section presents the results and discusses the decisions, challenges, and refinements made throughout the development process.

1. Analysis phase

The Analysis phase focused on identifying the need for a handout, understanding the target users' characteristics, and determining the content requirements. A needs assessment questionnaire was distributed to 15 students. The questionnaire comprised both quantitative Likert-scale items (1 to 5 scale) and qualitative open-ended questions to capture students' perspectives on current learning materials and their expectations for a handout. Table 1 presents the descriptive statistics for the items assessing students' perceptions of current materials and the importance of developing a handout. Students rated their satisfaction with the current

learning materials (journal articles and e-books) on the Assessment in Science course as relatively high ($M = 4.20$, $SD = 0.68$), suggesting that they generally found the existing resources accessible and useful for general reference. Similarly, students rated the materials' adequacy in supporting their understanding highly ($M = 4.00$, $SD = 0.53$). However, these relatively high satisfaction scores should be interpreted with caution. The existing materials, primarily journal articles and e-books, are general academic resources that were not specifically designed for the Assessment in Science course. Students may have rated them positively due to familiarity rather than a genuine pedagogical fit, as they lacked direct comparison with more structured, course-specific materials. This interpretation is supported by the high importance rating for a dedicated handout ($M = 4.33$, $SD = 0.72$), suggesting that while students were satisfied with the existing resources, they recognised the need for a handout. According to Sohail et al. (2024), learning materials such as a handout would further enhance their learning experience by providing organized and contextualized content specifically designed for this course.

Table 1. Needs Assessment Quantitative Results

Item	Mean (SD)	Scale
How satisfied are you with the current learning materials (i.e., journal articles and ebook in Google Drive) provided in the Assessment in Science course?	4.20 (0.68)	1 to 5 (Very unsatisfied to Very satisfied)
Do you feel the current learning materials adequately support your understanding of the course content?	4.00 (0.53)	1 to 5 (Strongly disagree to strongly agree)
How important is a handout for your understanding of the course material in Assessment in Science?	4.33 (0.72)	1 to 5 (Not important at all to very important)

Regarding the length of the handout, 60% of students preferred 5 to 6 pages per topic, suggesting that students need comprehensive coverage of content in a handout without an overwhelming length. Brazeau (2006) suggested that handouts should be concise in order to encourage active learning, as extensive handouts may instead lead to passive learning and diminish students' ability to organize information effectively. Furthermore, students most frequently requested two specific components: "summary of key theories or concepts" (93%) and "case studies or real-world applications" (93%). This finding indicates students' desire for materials that both include key theoretical knowledge and demonstrate practical applications in science education contexts. Assessment literacy involves both knowing assessment principles (declarative knowledge) and applying them in practice (procedural knowledge), which aligns with the components requested by students (Dehqan & Sorkhi, 2020). Additionally, 67% of students wanted "example problems and solutions" and "step-by-step guides to develop each type of assessment," which reflects students' need for concrete guidance in assessment development. All students (100%) expressed interest in interactive elements, specifically links to videos or articles, indicating strong support for a digital format that integrates multimedia resources. This finding aligns with contemporary digital learning preferences and supports the decision to develop the handout in digital rather than print format.

Moreover, based on the responses to open-ended questions, some students requested clear organization with headings and subheadings for improved readability, concise explanations focusing on main points rather than excessive detail, learning objectives at the beginning of each section, and additional references for further exploration.

2. Design phase

Based on the need assessments from the Analysis phase, the Design phase focused on creating a comprehensive blueprint for the digital handout. In this phase, the instructional strategy was designed in line with constructivist learning principles, in which learners actively construct knowledge by connecting new information to prior understanding (Bada & Olusegun, 2015). Each chapter was structured to begin with clear learning objectives, followed by concise theoretical foundations, practical examples from science education contexts, a summary of key points, key terms for essential vocabulary, additional materials linking to external resources for further exploration, and review questions for self-assessment. This sequence supported the progressive construction of knowledge from foundational concepts to practical applications.

The digital handout comprised seven chapters that are (1) Assessing Students' Scientific Literacy, (2) Test Item Analysis Using IBM SPSS Statistics, (3) Assessing the 4C's 21st Century Skills Part 1, (4) Assessing the 4C's 21st Century Skills Part 2, (5) Assessing Students' Motivation and Self-Efficacy in Science, (6) Assessing Students' Argumentation and Affective, (7) Test Item Analysis Using WINSTEPS. Each chapter was designed to span 5-6 pages, aligning with student preferences. The visual interface utilized Arial font with chapter titles at 15-point bold, section headings at 15-point, subsections at 12-point bold, and body text at 12-point, ensuring readability across devices. A single-column layout was implemented to optimize reading flow. Navigation features included hyperlinks and QR codes that provided direct access to external resources such as sample assessments, video demonstrations, and supplementary materials.

3. Development phase

The Development phase involved constructing the actual digital handout based on the blueprint established in the Design phase. This included content writing, multimedia production, and digital integration through embedded hyperlinks and QR codes linking to external videos, sample assessments, diagrams, and infographics. The developed draft subsequently underwent expert judgment and readability testing. Regarding the expert judgment, the handout was reviewed by one faculty member specializing in science education and assessment. The suggestions included simplifying the handout writing, especially the statistical analysis sections, while highlighting important analytical steps; converting tutorial video links into barcodes for easier access; and revising the critical thinking framework used in the handout to align with Facione's framework (Facione, 2011). Since the expert judgment focused on obtaining descriptive suggestions and evaluative comments for revision purposes, the review was conducted qualitatively rather than quantitatively. This approach aligns with established practices in instructional materials development, where subject-matter expert review during the development phase serves an improvement-oriented rather than a measurement-oriented purpose (Dick et al., 2015).

In terms of readability testing, three students from the 2022 batch who had previously completed the Assessment in Science course served as respondents. The qualitative feedback

is presented in Table 2, covering five aspects: grammatical correctness, clarity and conciseness of language, vocabulary choices, spelling or writing errors, and the use of complex terms. Based on the feedback from both expert judgment and readability test, revisions were made to the handout before implementation.

Table 2. Summary of the readability test results

Evaluation aspect	Summary
Grammatical correctness	The grammar used in the handout was considered appropriate and understandable. However, several students suggested minor grammatical revisions, such as adding auxiliary verbs, improving sentence structure, and correcting sentence flow.
Clarity and conciseness of language	Students found the explanations understandable, but some sentences were considered too long or difficult to follow. Respondents suggested separating long sentences into shorter ones to improve clarity.
The choices of words	Students identified several academic or technical terms that were unfamiliar or difficult to understand, such as <i>refutation</i> , <i>priori</i> , <i>nuanced</i> , and <i>debilitating</i> . However, the vocabulary was generally still considered suitable for university-level students.
Spelling or writing errors	A few typographical and punctuation errors were identified, such as repeated words (" <i>eigenvalue value</i> "), missing commas, and inconsistent spacing or formatting.
The use of complex terms	Most suggestions recommended simplifying certain words or providing clearer explanations to support comprehension.

4. Implementation phase

The digital handout was implemented in the Assessment in Science course, with 28 undergraduate science education students from the 2023 batch as the target users. Prior to implementation, a brief orientation session was conducted by the researchers to familiarize students with the handout's structure, navigation features, and multimedia elements, ensuring that they could effectively utilize all components during learning. The handout was published using Flip HTML5, and the access link was embedded in the university's official Learning Management System (LMS), SPOT UPI, allowing students to access the handout seamlessly through the platform they regularly use for coursework. Students were then encouraged to independently explore the handout, familiarize themselves with its interactive features, including embedded hyperlinks and QR codes, and subsequently use it collaboratively the Assessment in Science course meetings. Throughout the implementation, the course lecturer monitored and guided the students. Figure 2 shows the cover and a representative sample of the handout's content.

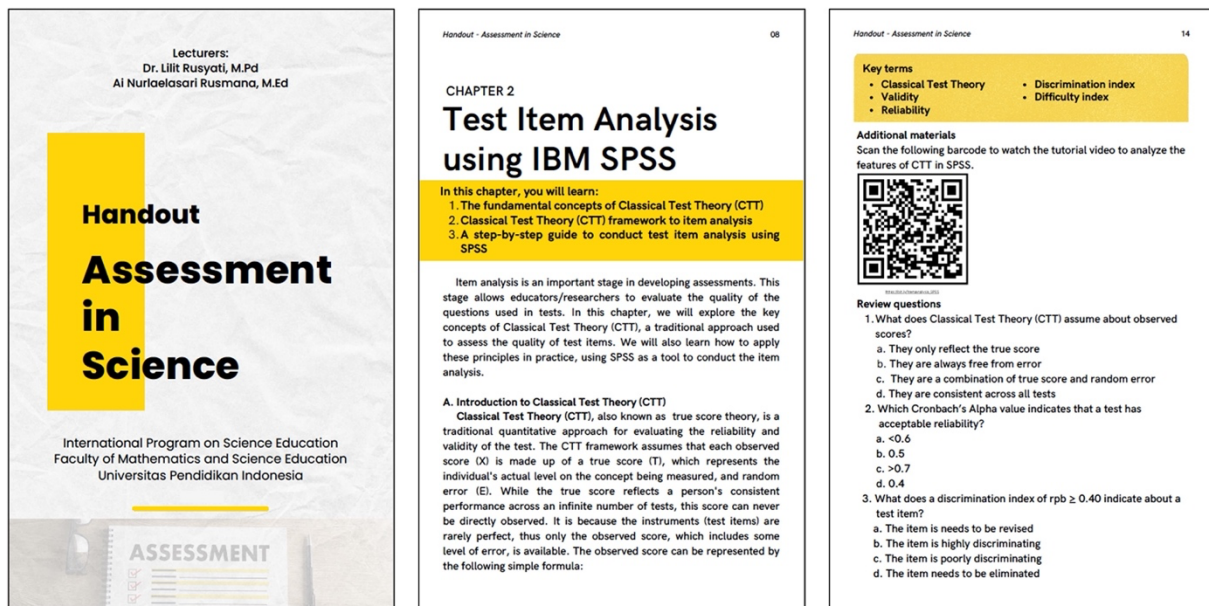


Figure 2. Cover and representative content sample of the digital handout

5. Evaluation phase

Following the implementation, the 28 students who had used the digital handout during the Assessment in Science course completed a practicality questionnaire to evaluate their experience. The questionnaire consisted of ten items: seven quantitative Likert-scale items (1 = strongly disagree to 5 = strongly agree) and three qualitative open-ended questions. The Likert-scale items assessed: (1) clarity and understandability of information, (2) organization and ease of following content, (3) appropriateness of detail level for learning, (4) effectiveness of examples in supporting concept understanding, (5) usefulness of visual aids in facilitating comprehension, (6) effectiveness in supporting class activities, and (7) likelihood of future reference for reviewing assessment concepts. The three open-ended questions explored what students found most helpful or useful about the handout, suggestions for improvement to better support understanding of assessment concepts, and whether the handout raised further questions or topics they wished to explore. Quantitative data were analyzed using descriptive statistics, calculating mean scores and standard deviations for each item and overall practicality, which are presented and discussed in the following section addressing the second research question.

Practicality Evaluation of Digital Handout

The second research question examined the practicality of the developed digital handout based on students' evaluation following its use in the Assessment in Science course. A practicality questionnaire consisting of seven Likert-scale items and three open-ended questions was administered. The quantitative results of the item response distribution are presented in Figure 3, while the qualitative findings support them.

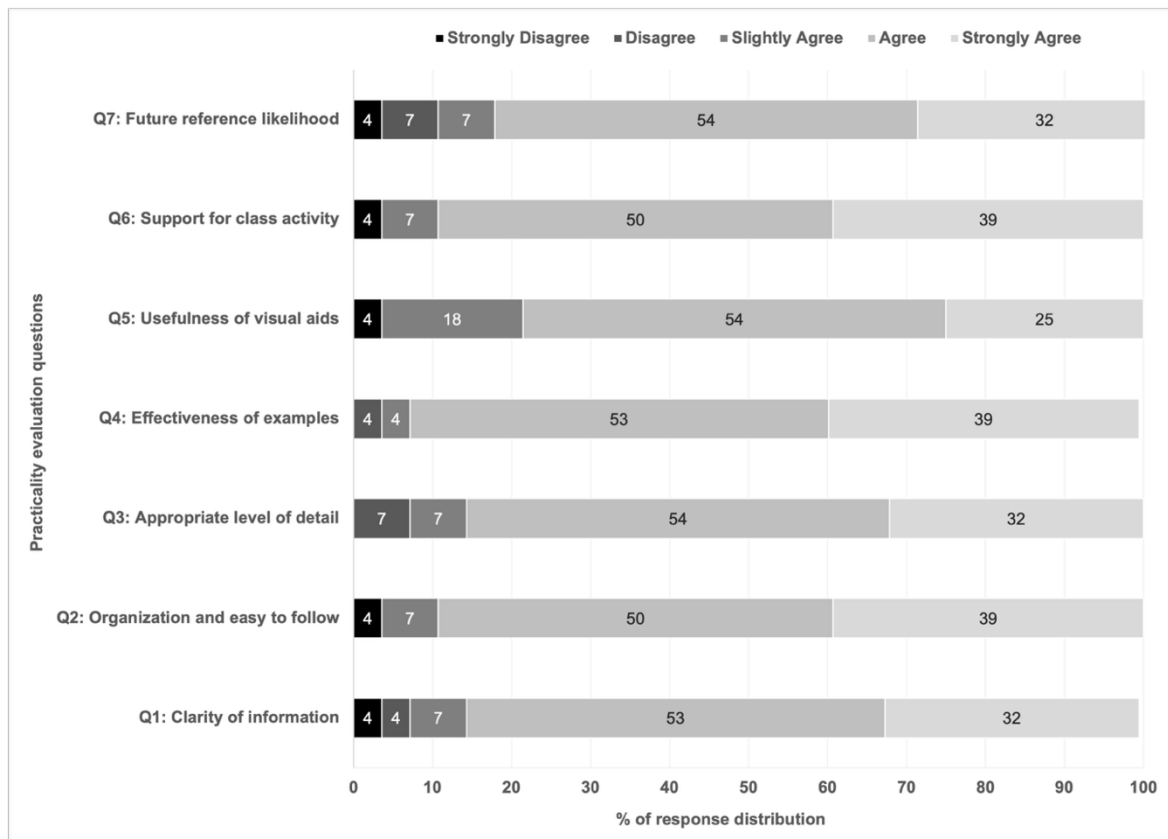


Figure 3. Response distribution per practicality items

Overall, the digital handout was rated as practical by students, with an overall mean score of 4.17 ($SD = 0.82$) on a 1 to 5 scale. These findings are consistent with previous studies reporting high practicality ratings for digital learning materials developed through systematic instructional design approaches (Puchkova et al., 2021). As illustrated in Figure 3, all seven items received mean scores above 3.96, indicating consistently positive evaluations across all assessed dimensions of the handout. The two highest-rated items were Question 4 (Q4), the effectiveness of examples in supporting concept understanding ($M = 4.29$, $SD = 0.71$, with 92% of students rating agree or strongly agree), and Q7, the likelihood of future reference for reviewing assessment concepts ($M = 4.29$, $SD = 0.76$, with 86% of students rating agree or strongly agree). These results suggest that the developed digital handout fulfilled two core functions: providing contextually relevant examples of science assessment and acting as a durable reference resource for learning assessment (Zafeer et al., 2025). This is also supported by a student's answer to an open-ended item about the assessment topic they would like to explore. The student expressed interest in seeing more examples of test items in real assessments. According to prior studies (Bahtaji, 2015; Dewi & Primayana, 2019; Sarifayani & Haqq, 2022), the presence of contextual examples increases students' conceptual understanding because it intrigues their interest, helps them contextualize the concepts and relate them to real-life situations.

Next, effectiveness in supporting class activity (Q6) also received a high rating ($M = 4.25$, $SD = 0.75$, with 89% students responding agree to strongly agree), indicating that the handout successfully fulfilled its intended role as an in-class learning companion. This finding also suggests that integrating the handout into classroom activities through SPOT (Sistem

Pembelajaran Online Terpadu), UPI's official learning management system, facilitated smooth adoption; therefore, students were able to access and navigate the content effectively during lessons. The accessibility afforded by the digital format, consistent with Mayer's (2021) principle that learning materials should support flexible access across contexts, likely contributed to this positive outcome. Q2, concerning the organization and ease of following the content ($M = 4.21$, $SD = 0.88$), and Q3, concerning the appropriateness of the level of detail ($M = 4.11$, $SD = 0.83$), also received positive scores, suggesting that students found the handout well-structured and appropriately comprehensive for their learning needs. Based on students' responses to the open-ended item about the most helpful aspect of the handout, the majority appreciated that the handout presented complex assessment concepts in simple and direct language without unnecessary elaboration. Students also valued bold formatting to highlight important terminology in the text. In Zhang's study (2024), the use of digital instructional materials could improve students' comprehension by reducing cognitive load and facilitating information processing. The feature serves as a cognitive scaffold, making the materials easier to navigate and understand. This is aligned with the following students' testimony.

[P#16] *"The sentences are short and straight to the point, which is clear and easy to understand"*

[P#17] *"This handout has simpler language and explanations so that it is very easy to understand. The materials are also fairly complete"*

[P#25] *"The keywords are written in bold, so it really helped me to read it."*

Furthermore, clarity of information (Q1) received a mean score of 4.07 ($SD = 0.94$), which, while still within the practical range, showed the highest variability among all items, indicating some inconsistency in students' experiences with the clarity of explanations across different chapters. On the other hand, Q5, the usefulness of visual aids ($M = 3.96$, $SD = 0.88$), had the lowest rating. The qualitative data, especially responses to the item about suggestions for improvement, provided an explanation for this finding. In this case, students specifically mentioned issues related to image resolution when zooming on digital devices and insufficient spacing around visual elements. This suggests that while the conceptual design of the visual aids was appropriate, the technical execution (i.e., image quality and layout spacing) requires improvement in future revisions. This finding aligns with Mayer's (2021) coherence principle, which emphasizes that visual elements must be carefully designed to genuinely support rather than distract from learning, as poorly rendered images may undermine the potential benefits of multimedia integration. In the context of science education, Qomi (2024) also emphasize that high-resolution images are essential for maintaining clarity and ensuring that visual elements are not distorted as images may convey important information for learning.

Conclusion

This study developed a digital handout for the Assessment in Science course using the ADDIE model. The findings indicate that the handout was practical for use in the course, particularly in supporting concept understanding, classroom learning, and future review. Nevertheless, several technical aspects, especially the quality of visual elements and layout spacing, require further improvement. Overall, the digital handout shows potential as a learning

resource to support assessment literacy among preservice science teachers. From an academic perspective, this study adds to the growing body of literature on digital instructional materials in higher-level science education. In particular, it demonstrates that systematically developed and course-specific digital handouts can effectively bridge the gap between generic academic resources and the structured learning needs of pre-service science teachers. The findings support the ADDIE model's relevance as a framework for creating practical digital learning materials in undergraduate science teacher education programmes, where assessment literacy is a critical yet frequently under-resourced competency. Future studies are encouraged to examine the digital handout's effectiveness in improving students' assessment literacy outcomes rather than its practicality alone. Furthermore, involving larger, more diverse groups of participants from different teacher education institutions would strengthen the generalizability of the findings. The validity of the handout would also benefit from quantitative validation using a standardized instrument. Last, future research should prioritize improving the technical quality of visual elements, including image resolution and layout design to optimize multimedia learning potential of the digital format.

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