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Development of a Bilingual E-LKPD for Teaching A'dad (عَدَد) Numbers to Arabic Language Education Students

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Abstract

Learning *a'dad* (numbers and the four arithmetic operations in Arabic) is challenging for Arabic Language Education students because the numerical systems of Arabic, Indonesian and mathematics differ, and technology-based teaching media are limited. This study developed a bilingual (Arabic–Indonesian) Electronic Learner Worksheet (*Lembar Kerja Peserta Didik Elektronik*, E-LKPD) on *a'dad* and examined its validity, practicality and effectiveness. Design research of the validation-studies type was used, comprising preliminary design, a design experiment (pilot and teaching experiments) and retrospective analysis; formative evaluation (self-evaluation, expert review, one-to-one, small-group and field tests) was embedded within these stages. Expert validation rated the product as very valid (material experts 94.5%; media expert 92.0%). Practicality was rated very practical in the one-to-one trial (94.67%, n = 3) and the small-group trial (88.67%, n = 6). In the field test (n = 27), 25 students (92.59%) scored at least 70 on a five-item post-test, which falls in the 'very effective' category. Because the field test used a post-test only, the results are interpreted as preliminary evidence of validity, practicality and student achievement in one class, not as evidence of causal learning gains; a pre-test/post-test or comparison design is recommended for future studies.

Keywords: Bilingual E-LKPD; a'dad; design research; validation studies; Arabic Language Education

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1. Introduction

Arabic learning in higher education is still hampered by several fundamental obstacles. Students often face difficulties and lack internal motivation, largely because of the sharp structural differences between the Arabic and Indonesian language systems, so that mastery requires specific and well-directed learning strategies (Syauqillah & Hilmi, 2021). In addition, mathematical competence is part of the preparation of prospective Arabic teachers, because errors in understanding mathematical symbols can lead to the misapplication of concepts as a whole. A closer examination of the meeting point between mathematical reasoning and Arabic language learning is therefore needed.

One of the crucial topics in the Arabic Language Education curriculum is *a'dad* (numbers) together with *ma'dud* (the counted noun). In the PBA curriculum, this topic covers the four arithmetic operations (addition, subtraction, multiplication and division) on numbers expressed in Arabic. Mastery of this topic is fundamental because numbers are a basic element of linguistic construction, while the many forms of Arabic numerals call for a concise learning method that can sustain students' enthusiasm; (Ginting et al., 2024), for example, used mind mapping to increase students' motivation in learning *'adad ma'dud*. *A'dad* is also closely connected with the daily practice of Muslims, and (Nazrailman et al., 2024) examined its learning through a combination of YouTube and Quizizz for the digital-native generation. However, students often perceive this topic as difficult because it requires adjustment to mathematical reasoning. Contributing factors include teaching methods with little creativity, limited conceptual understanding of the underlying mathematics, a shortage of attractive technology-based media, and the differences in how Arabic and Indonesian express numbers and counted objects (Syauqillah & Hilmi, 2021).

Advances in digital technology have opened up opportunities to improve the quality of Arabic language learning. One of them is the Electronic Learner Worksheet (*Lembar Kerja Peserta Didik Elektronik*, E-LKPD), which offers interactivity, easy access and the integration of multimedia elements such as audio, video and animation. Digital worksheets and mobile-based materials have already been developed for Arabic learning, for example Android-based Arabic student worksheets for grade XII of madrasah aliyah (Azzahra, 2024), mobile-learning-based Arabic teaching materials (Iman et al., 2021) and contextual electronic worksheets (Abiyyah et al., 2025). Building on this line of work, a bilingual E-LKPD may help students overcome their difficulties with *a'dad*, because presenting the material in two languages can make the concepts and terms easier to process. Evaluation instruments for Arabic worksheets have also been developed to improve the effectiveness of Arabic learning (Jannah et al., 2025).

Evidence from neighbouring studies points in the same direction, although each line of work covers only part of the problem. In mathematics education, worksheets built on realistic or contextual tasks have produced measurable gains: an RME-based worksheet improved senior high school students' problem-solving more than conventional instruction in a pretest–posttest control-group study (Manggarrani & Marhaeni, 2025), and a differentiated Liveworksheets E-LKPD reached high validity and a moderate N-gain in junior high school students' statistical literacy (Muliawanti et al., 2026). (Choirudin et al., 2021) showed that cultural–visual elements such as calligraphy can

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be woven into guided-discovery mathematics worksheets. In Arabic education, a contextual Liveworksheet E-LKPD significantly raised madrasah students' comprehension of the *as-safar* topic (Al-ghozali, 2025), while STAD-based worksheets for *hiwar* (Hayati et al., 2022) and contextual grammar materials in an Islamic boarding school (Rahmah & Hasanah, 2024) confirm that structured, context-rich tasks support Arabic learning. Bilingual modules, for their part, have been associated with higher motivation to learn mathematics (Nurhayati, n.d.).

Research on mathematics learning in more than one language helps explain why such tasks may matter for *a'dad*. Bilingual learners use both of their languages, together with gestures, objects and drawings, as resources for building mathematical meaning, so moving between languages is better treated as a support than as a deficit (Moschkovich, 2002); classroom studies in multilingual settings likewise show that switching languages can serve conceptual as well as social purposes (Setati & Adler, 2000). (Duval, 2006) adds that understanding in mathematics depends on coordinating at least two registers of representation for the same object, because learners who treat each register separately tend to see unrelated tasks rather than one concept. In *a'dad*, these registers are the Arabic number word with its *ma'dud* agreement, the Indonesian number word, and the numeral or equation. Indonesian design research grounded in PMRI has shown how such coordination can be built gradually: a traditional-game context helped third graders move from informal counting to formal multiplication (Prahmana & Hartono, 2012), and PMRI has been introduced nationally as a reform built on contextual problems and students' own strategies (Sembiring & Hadi, 2008). These studies rely on learning trajectories, that is, conjectured routes of learning activity that are tested and revised in the classroom (Simon, 1995), (Clements & Sarama, 2004), which makes design experiments a suitable vehicle for developing materials of this kind (Cobb et al., 2003).

Read together, these findings leave a specific gap. The E-LKPD studies above target either Arabic language skills or mathematics, and they are presented in a single language, while the work on bilingual learning and representation (Duval, 2006; Moschkovich, 2002) explains why linking languages with models should help but has not yet been applied to Arabic number words. Earlier studies on *'adad ma'dud* used mind mapping (Ginting et al., 2024) or a YouTube–Quizizz combination (Nazrailman et al., 2024) and digital Arabic worksheets have been produced mainly for school learners (Azzahra, 2024; Mahara, 2023), rather than for prospective Arabic teachers. To the authors' knowledge, no study has documented how an electronic worksheet that presents *a'dad* in Arabic and Indonesian alongside mathematical models and contextual tasks is designed, tested and refined through design research. The present study addresses that gap. Its contribution lies not in the worksheet alone but in the combination of (a) bilingual Arabic–Indonesian representation of the same quantity, (b) PMRI-informed contextual tasks that link number words to mathematical models, and (c) an empirically refined hypothetical learning trajectory (HLT) from which design principles for a local instructional theory (LIT) are derived.

Conceptual framework. The study connects the learning problem to the design through three ideas. First, *a'dad* requires learners to coordinate three representations: Arabic number words that agree grammatically with the *ma'dud*, Indonesian number words, and mathematical numerals and operations. Bilingual presentation is therefore intended as representational support: the same

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quantity is shown in both languages next to a mathematical model, so that students can map terms across languages instead of memorising them separately (Duval, 2006; Moschkovich, 2002). Second, the tasks follow PMRI principles (Fauziah et al., 2020): contextual problems as starting points (for example, sharing objects into equal groups), the use of students' informal strategies and visual models, progressive mathematisation from context to formal notation, interaction, and intertwining of mathematics with language.

Third, constructivist and sociocultural views inform the design rationale. The constructivist premise that new knowledge is built on existing schemas (Piaget, 1972) motivated anchoring new Arabic terms in the Indonesian and mathematical knowledge students already hold, and the view that learning is mediated by social interaction (Vygotsky, 1978) motivated group tasks in the small-group and field-test phases. The intended mechanism of improvement is therefore: bilingual representation plus contextual models → mapping between terms and quantities → conceptual and procedural understanding of *a'dad*.

Based on this background, the study addressed three research questions: (1) How was the bilingual E-LKPD on *a'dad* designed and refined for Arabic Language Education students? (2) To what extent is the product valid and practical according to expert review and one-to-one and small-group trials? (3) What evidence from a field test supports its effectiveness, defined here as students' achievement of a predetermined mastery criterion on a post-test after using the E-LKPD? The study aims to develop a bilingual E-LKPD intended to facilitate students' intrinsic motivation, conceptual understanding and procedural skills in *a'dad*, and to derive preliminary design principles (a local instructional theory) from the design experiment. The study is expected to contribute at two levels. Theoretically, it carries the PMRI design-research tradition, which has so far focused mainly on school mathematics and on the preparation of primary teachers (Fauziah et al., 2020; Prahmana & Hartono, 2012), into number learning within Arabic Language Education, and it examines in a new setting the claim that coordinating representations supports conceptual understanding (Duval, 2006); the refined HLT and the four design principles in Section 3.1.6 are offered as a preliminary local instructional theory for bilingual *a'dad* learning. Practically, it supplies PBA lecturers with a bilingual E-LKPD that has been expert-validated and tried out in three successive trials, together with a documented record of the revisions made at each stage, which developers of Arabic teaching materials can reuse or adapt.

2. Methods

2.1 Research Design and Methodological Framework

This study used design research of the validation-studies type (Bakker & Van Eerde, 2014; Plomp, 2013), a development-research approach aimed at building a local instructional theory (LIT) on *a'dad* and explaining how the designed learning materials work in practice. The approach was chosen because it allows repeated cycles of designing, testing and refining, so that the final product is empirically tested before wider use, and because the conjectures behind each task are written down in a learning trajectory that can be checked against what students actually do (Cobb et al., 2003; Gravemeijer, 1994; Simon, 1995). It is regarded as effective for building a knowledge base

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for teachers and teaching in mathematics education, because researchers produce not only products but also local learning theories that are contextual to the classroom studied (Gravemeijer, 2009).
The study used a mixed approach. Qualitative data (observation notes, interviews, video recordings, documentation and students' work) were used to analyse the learning process and to revise the HLT and the E-LKPD. Quantitative descriptive data (expert ratings, practicality questionnaires and a post-test) were used to describe the validity, practicality and achievement associated with the product. The qualitative data were not reduced to percentages; their analysis is described in Section 2.6.
The research followed three stages (Figure 1): preliminary design (literature study and HLT design), the design experiment (a pilot experiment, revision, and a teaching experiment), and retrospective analysis. The results of each stage informed the next. Within these stages, the product was evaluated through a formative-evaluation sequence (Tessmer, 2013) of self-evaluation, expert review, one-to-one trial, small-group trial and field test. Table 1 shows how these procedures map onto the design-research stages.

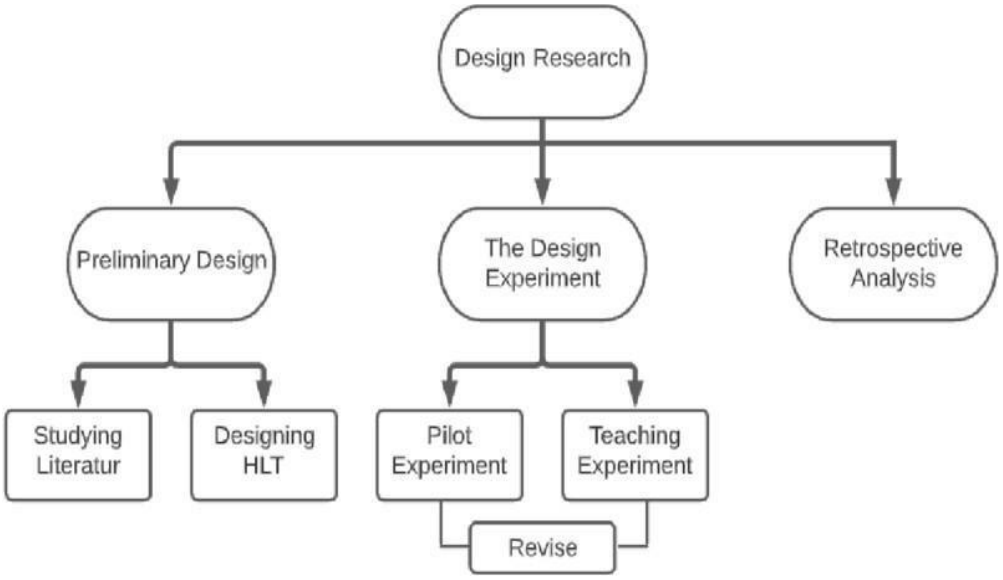


Figure 1. *Design Research* Flow of *Validation Studies Type*

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Table 1. Mapping of the formative-evaluation procedures onto the design-research stages

Design-research stage	Procedures reported in this article	Participants	Data and analysis
Preliminary design	Needs analysis; literature study (PMRI); HLT formulation; prototype development and self-evaluation	30 semester-3 PBA students, purposive sampling (needs analysis); researchers	Questionnaire and observation notes (descriptive); literature synthesis
Design experiment: pilot experiment	Expert review; one-to-one trial; small-group trial; revision of HLT and prototype	3 experts (2 material, 1 media); 3 students; 6 students	Validation sheets and practicality questionnaires (percentage scores); observations, field notes, interviews and video (data reduction, data display, conclusion drawing)
Design experiment: teaching experiment	Field test of the revised E-LKPD in a regular class	27 students (one full class)	Post-test (mastery percentage, descriptive statistics); classroom observation and video
Retrospective analysis	Comparison of the HLT with actual learning; formulation of design principles (LIT)	All data sources	Qualitative analysis: data reduction, data display and conclusion drawing; comparison of the HLT with observed learning

2.2 Preliminary *Design* Stage

In this stage the researchers reviewed the literature on *a'dad* using a contextual approach based on Indonesian Realistic Mathematics Education (PMRI). The review aimed to identify the essential concepts to be taught and the learning approach most relevant to the characteristics of Arabic Language Education (PBA) students. On this basis, the researchers compiled a Hypothetical Learning Trajectory (HLT), that is, a conjectured sequence of learning activities for *a'dad* linked to contexts from students' daily lives. The HLT followed the framework for developing a PMRI-based learning environment through lesson study for prospective primary school teachers (Fauziah et al., 2020), which stresses designing a hypothetical trajectory before testing it with research participants. The initial HLT is presented in Section 3.1.1.

Needs analysis. Before the design, a needs analysis was carried out through observation and an online questionnaire (Google Forms) distributed to Arabic Language Education (PBA) students at UIN Sulthan Thaha Saifuddin Jambi (30 students; all in semester 3 and selected by purposive sampling). The analysis focused on three aspects: (1) the need for interactive digital teaching material that bridges the differences between the Indonesian, Arabic and mathematical number systems; (2) difficulty in understanding abstract material without concrete visualisation; and (3) the need for an electronic worksheet that can be accessed flexibly on students' own devices. The questionnaire contained five items rated on a five-point scale (1 = strongly disagree to 5 = strongly agree): items 1–2 addressed aspect (1), items 3–4 aspect (2) and item 5 aspect (3). All 30 students returned complete responses, so no case was excluded, and the responses were analysed descriptively as percentages (Section 2.6). A literature study and benchmarking of existing E-LKPD development models, contextual mathematics applications and suitable digital platforms complemented the questionnaire.

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2.3 The *Design Experiment* Stage

The design experiment consisted of a pilot experiment and a teaching experiment. The pilot experiment tested the initial HLT and prototype with a small group of Arabic Language Education students in order to collect data for improving them; it comprised the expert review, the one-to-one trial (n = 3) and the small-group trial (n = 6), with the researcher acting as the teacher in the two student trials. After the HLT and E-LKPD were revised on the basis of the pilot findings (Figure 1), the teaching experiment was carried out as a field test in a regular class to examine the revised product more comprehensively.

2.4 *Retrospective Analysis* Stage

The third stage was a retrospective analysis of the whole set of experiments. All data from the trials were analysed in depth (Section 2.6), and the results were used to compare the HLT with students' actual learning, to identify where the HLT's conjectures held or needed revision, and to formulate design principles that form a preliminary local instructional theory (LIT) for teaching *a'dad* with a bilingual E-LKPD in the studied class context.

2.5 Research Subjects and Instruments

The study was conducted in the PBA study programme of UIN Sulthan Thaha Saifuddin Jambi in 2025: the needs analysis was carried out on 5–12 June 2025, the one-to-one and small-group trials on 7–14 August 2025, and the field test on 8–15 September 2025. Different participants took part at each stage (Table 1). *Expert review.* Three experts validated the product. Two were material experts: an Arabic linguist (Dr., M.Pd.I), who assessed whether the Arabic sentence structures in the E-LKPD were correct, and a mathematician (M.Si), who assessed the accuracy of the mathematical concepts, the appropriateness of the contexts and the suitability of the material for PBA students. The third was a media expert, a lecturer in information technology, who assessed the ease of navigation (usability), the consistency of the visual design, the quality of the layout and the interactivity of the media. The two material experts were from UIN Sulthan Thaha Saifuddin Jambi and had 15 years of experience, whereas the media expert was from Universitas Dinamika Bangsa and had 10 years of experience. The single 'material' score was obtained by averaging the percentage scores given by the two material experts. Expert validation of digital Arabic learning content is a common step in development studies (Amiruddin, 2022). The validation sheet was developed from product-feasibility indicators (for the material: alignment with the curriculum and learning outcomes, accuracy of mathematical concepts, currency of the material and clarity of language; for the media: ease of navigation, consistency of visual design, layout quality and interactivity; 25 items per validation sheet) and used a four-point scale (1–4), with space for qualitative suggestions and criticism on each aspect. The four points were defined as 1 = not appropriate, 2 = less appropriate, 3 = appropriate and 4 = very appropriate. Each validator worked

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independently on the online version of the E-LKPD, accompanied by the HLT and the validation sheet, so that one expert's ratings did not influence another's.

One-to-one and small-group trials. Three PBA students of high, medium and low ability (selected on the basis of their performance in previous courses) took part in the one-to-one trial. They used the E-LKPD individually and in stages, and the researcher observed them while they voiced their thoughts aloud. A practicality questionnaire (five items; five-point scale, 1–5) collected feedback on (1) the clarity of instructions, (2) ease of navigation on the digital platform and (3) the helpfulness of the mathematical context. Six representative PBA students (selected on the lecturer's recommendation and course-evaluation results, which identified two students of high, two of medium and two of low ability in the mathematics course) took part in the small-group trial, using the E-LKPD simultaneously in a setting resembling a real lecture while the researcher observed their interaction and collaboration. The questionnaire in this trial covered engagement, interest, motivation and perceived ease of use and usefulness. All trial participants were semester-3 students, and students who took part in the one-to-one or small-group trials did not take part in the field test.

Field test. The field test involved one full class of 27 PBA students who had not used the material before. The E-LKPD was used in one learning session led by a PBA lecturer, who integrated it as the main learning resource, while the researchers acted as facilitators and observers. After the session, a post-test of five items (multiple-choice and essay items; the blueprint followed the material, namely addition, subtraction, multiplication and division; reliability coefficient = 0.82; validated by the team of lecturers of the course) was administered. Students who did not reach the mastery criterion were interviewed. Because no pre-test or comparison group was used, effectiveness is defined operationally as achievement of the mastery criterion described in Section 2.6; it is not interpreted as a causal learning gain.

Data collection procedure. The same sequence was followed at every stage so that the procedure can be repeated. (1) In the expert review, each validator received the E-LKPD link, the HLT and the validation sheet; every item rated 1 or 2 and every written comment was entered in a revision log and resolved before the student trials began. (2) In the one-to-one trial, each student worked through the E-LKPD separately while thinking aloud; the researcher kept field notes, asked brief probing questions only after each activity so as not to interrupt the student's reasoning, and administered the practicality questionnaire at the end of the session. (3) In the small-group trial, the six students worked in a single session, presented their answers to the group and then completed the questionnaire, and the session was video-recorded. (4) In the field test, the lecturer taught one session with the revised E-LKPD, the post-test was taken individually at the end of that session, and the students below the mastery criterion were interviewed afterwards with a semi-structured guide on perceived difficulty, language support and the use of the interactive features. After each stage, the research team compared the observations with the HLT conjectures and agreed on the revisions, which are summarised in Tables 3 and 5.

Post-test scoring and ethics. Multiple-choice items were scored as correct or incorrect, and essay items were scored with an analytic rubric that credited the correct operation, the correct Arabic number word and *ma'dud* form, and the final answer, so that partial credit was possible; the total

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was converted to a 0–100 scale. Because the test combined dichotomous and polytomous items, its reliability (0.82) was estimated with Cronbach's alpha. Participation was voluntary, the purpose of the study was explained to all students beforehand, and names were replaced with codes in all field notes, transcripts and score sheets.

2.6 Data Analysis

Validity, practicality and effectiveness scores were converted to percentages with the formula P = (sum of obtained scores / sum of maximum scores) × 100%. For expert validation, the maximum score was 100 (25 items × 4) per expert, and the two material experts' scores were averaged to give the single material score (combined score against a combined maximum of 200). For the practicality questionnaires, the maximum was the number of students × number of items × 5, that is, 3 × 5 × 5 = 75 in the one-to-one trial and 6 × 5 × 5 = 150 in the small-group trial. For the needs analysis, the score of each aspect was the sum of all students' responses to the items in that aspect divided by 30 × number of items × 5 (300 for aspects 1 and 2; 150 for aspect 3). All percentages were computed from these raw totals and rounded to two decimal places, and the same values are reported in the abstract, text and tables. Percentages were classified using the criteria in Table 2 (Akbar, 2013). Effectiveness was defined as the percentage of students who scored at least 70 (the mastery criterion) on the five-item post-test; 25 of 27 students did so, giving 92.59%. Descriptive statistics (mean, standard deviation, minimum and maximum) are reported for the post-test.

Table 2. Criteria for interpreting percentage scores

Percentage	Validity	Practicality	Effectiveness
81–100	Very valid	Very practical	Very effective
61–80	Valid	Practical	Effective
41–60	Fairly valid	Fairly practical	Fairly effective
21–40	Less valid	Less practical	Less effective
0–20	Not valid	Not practical	Not effective

Qualitative data (observation notes, interview transcripts, video recordings and students' written work) were analysed in three stages (Miles & Huberman, 2014): data reduction, data display and conclusion drawing. Data reduction included transcribing the interviews, coding the field notes and selecting the observed student behaviour; the reduced data were then displayed and used to draw conclusions about revisions to the HLT and the E-LKPD. To maintain the trustworthiness of the data, source triangulation was used by comparing observation data, field notes and in-depth interviews with students and validators.

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3. Results and Discussion

3.1 Results

3.1.1 Preliminary Design: Needs Analysis and Initial HLT

The needs analysis (30 PBA students; questionnaire available at https://forms.gle/ZJQxjgBtVWPMKXyeA) revealed three main findings, each expressed as the summed score of the aspect divided by its maximum score: (1) the need for interactive digital teaching material that bridges the differences between the Indonesian, Arabic and mathematical number systems reached 88.33% (265 of 300); (2) difficulty in understanding abstract material without the help of concrete visualisation reached 82.00% (246 of 300); and (3) agreement that an electronic worksheet that can be accessed flexibly on students' own devices should be developed reached 91.33% (137 of 150). These findings became the blueprint for the design stage.
Table 3 presents the HLT, which sequences the four operations of *a'dad* from contextual problems to bilingual formal notation, together with the conjectured student reasoning and what was observed. Each stage is linked to a PMRI principle (Fauziah et al., 2020). In the one-to-one stage only minor revisions of detail were needed, and the small-group stage led to the last major revision of the design and content (Sections 3.1.3 and 3.1.4).

Table 3. Initial HLT, observed learning and revisions

HLT stage (PMRI principle)	Learning activity and bilingual term	Conjectured student reasoning	Observed in the trials and revision
1. Addition, *al-jam'* (contextual problem; informal strategies)	Combine two groups of pictured objects (e.g. two piles of books) and find the total; link the Arabic term *al-jam'* and the Indonesian *penjumlahan* to the same picture; write the sum with Arabic number words and the *ma'dud*	Students count all the objects, then count on from the larger group; the term beside the picture lets them link *al-jam'* with combining; they may hesitate over Arabic number words and the form of the *ma'dud*	Students initially tended to count the objects one by one from the beginning instead of directly using the number pattern that follows the 'adad–ma'dud rules. Revision: explanatory notes were added to the addition examples so that students link the visual form of the objects with the correct Arabic number pattern.

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HLT stage (PMRI principle)	Learning activity and bilingual term	Conjectured student reasoning	Observed in the trials and revision
2. Subtraction, *al-ṭarḥ* (modelling)	Remove part of a pictured group and find what remains; link *al-ṭarḥ* and *pengurangan* to the picture; record it first as a model and then as a number sentence	Students cross out or count back; they may confuse which quantity is taken away when reading the Arabic problem statement	Some students were confused about the direction of the Arabic mathematical sentence (read from right to left) when matching the remaining objects. Revision: the layout of the navigation arrows was clarified and the answer boxes were aligned with the reading direction of the Arabic–Indonesian text.
3. Multiplication, *al-ḍarb* (progressive mathematisation)	Find the total of several equal groups (e.g. rows of objects); move from repeated addition to the notation for multiplication; link *al-ḍarb* and *perkalian*	Students use repeated addition first and then recognise equal groups as multiplication; they may mix up the number of groups and the number in each group	Students were very enthusiastic when matching groups of objects but needed more time to write the multiplication equation in Arabic sentence structure. Revision: step-by-step guidance (scaffolding) was added to the digital worksheet before the independent practice items.
4. Division, *al-qismah* (contextual problem; interaction)	Share objects equally into groups (eggs in nests, penguins in igloos, chickens in cages; Figure 4), find the number in each group and complete the division equation; link *al-qismah* and *pembagian*; discuss answers with peers	Students share one by one and then connect sharing with the notation (e.g. 15 : 5 = 3); the bilingual instruction helps them read the Arabic task statement	In the small-group trial, students discussed actively but needed more time than planned; revision: clearer task instructions and time allocation aligned with actual working time (Section 3.1.4).
5. Integration (intertwining of mathematics and language)	Mixed bilingual contextual problems on the four operations with Arabic number words and the *ma'dud*, answer boxes with instant feedback, and pronunciation audio	Students solve the problems with models and then shorten to notation; students with limited Arabic fluency rely on the Indonesian text and the audio	25 of 27 students scored ≥ 70 on the post-test; the other two had limited Arabic fluency (interviews). Revision: a help button was added and the menu structure was aligned with the learning trajectory (Section 3.1.4).

3.1.2 Prototype Development and Self-Evaluation

On the basis of the needs analysis, the researchers developed the first prototype and carried out a self-evaluation before testing it with users. The prototype was designed in Canva: a worksheet

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template was selected, the page size was set, the *a'dad* material and its Indonesian equivalents were entered, graphic elements were added to visualise mathematical concepts, contextual visuals relevant to Muslims' daily lives were applied, animations were added and audio and video links were embedded. The file was then exported as an interactive PDF. The PDF was then uploaded to LiveWorksheets and converted into an interactive worksheet: answer text boxes with answer keys were created for the *a'dad* exercises so that students receive instant visual feedback, audio and video links were embedded to support the bilingual aspect and independent learning, and the link was shared with students for use on their own devices. Self-evaluation comprised three steps: (1) a review of content and linguistic consistency (the accuracy of *a'dad*, the rules of *'adad ma'dud* and the mathematical concepts relative to the PBA curriculum); (2) a functional test of the digital features (bilingual navigation buttons, pronunciation audio and explanatory videos) on different devices; and (3) an assessment of visual appeal, the layout of the bilingual text and font readability. The results were compiled into a revision list including improvements to the layout of the bilingual (Arabic–Indonesian) text, checks of the consistency of the 'adad–ma'dud rules, and tests of the navigation buttons and audio links so that they worked without technical problems. The cover is shown in Figure 2.



Figure 2. E-LKPD Cover Design

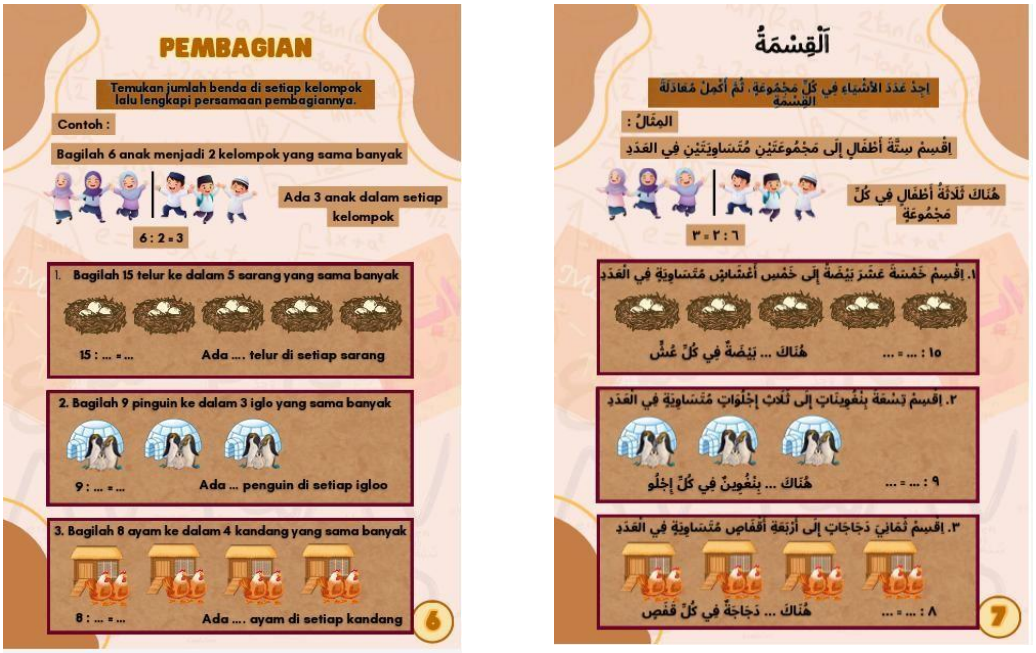
Figure 2 shows the cover of the bilingual E-LKPD (Arabic–Indonesian), titled 'Getting to Know the Concept of Numbers', with illustrations of Islamic characters and spaces for the user's name and class. Figure 3 shows the foreword and the learning-objectives page, which lists three indicators: the ability to explain the concepts of multiplication and division, the ability to solve contextual problems, and the growth of motivation and learning independence.

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Figure 3. Initial Design of E-LKPD

Figure 4 shows the division page with its Arabic equivalent (*al-qismah*), accompanied by visual models of groups of objects that help students understand division contextually, and an answer column for each exercise.



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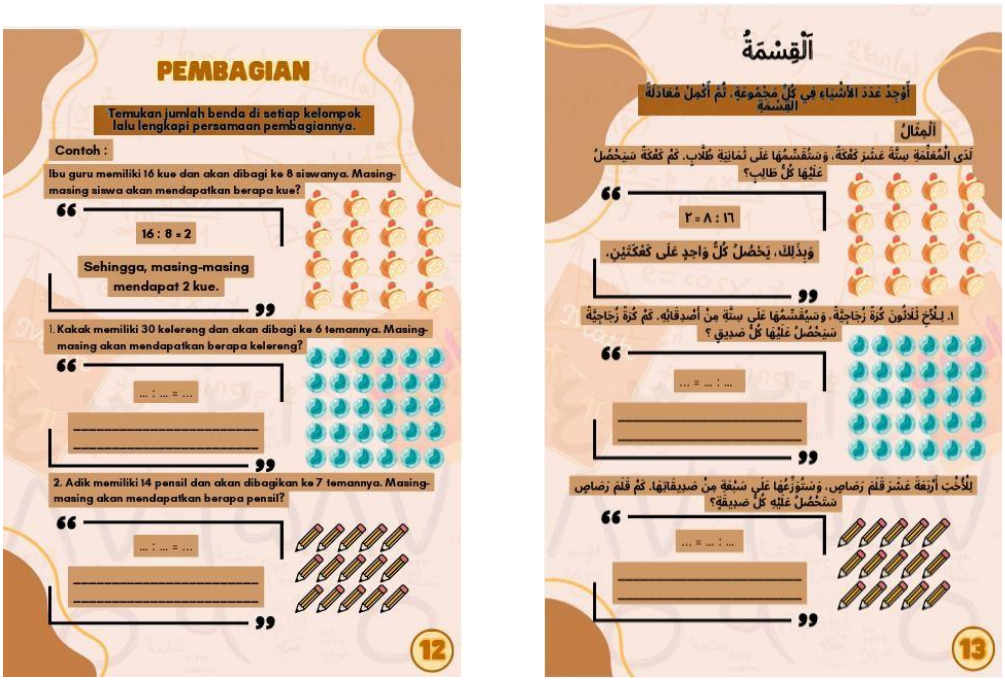


Figure 4. E-LKPD Content Design

3.1.3 Expert Review

Table 4 presents the expert ratings. The material experts (an Arabic linguist and a mathematician) gave a score of 94.5% and the media expert (an information-technology lecturer) 92.0%, both in the very valid category; the product was judged feasible for use with revisions. For the material experts, Validator I gave a score of 94 (94.0%) and Validator II a score of 95 (95.0%), a mean of 94.5%. In Table 4, the material row therefore reports the two experts' combined score (189) against their combined maximum (200 = 2 experts × 25 items × 4), whereas each validator's own maximum was 100; the media row reports a single validator's score against a maximum of 100. According to the validity conversion criteria of (Akbar, 2013), 94.5% falls in the range of 81–100% and is categorised as very valid, so the E-LKPD was considered very feasible and could proceed to the field trials. The experts' suggestions were used to improve the prototype before it was tried out with students, with the revisions focusing on sharpening the mathematical concepts and correcting the writing of Arabic terms and script.

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Table 4. Results of expert validation

Aspect	Indicators assessed	Items	Score / maximum	Percentage	Category
Material (Arabic linguist and mathematician)	Alignment with the curriculum and learning outcomes; accuracy of mathematical concepts; currency of the material; clarity of language	25 per expert (2 experts)	189 / 200 (combined; Validator I = 94 / 100; Validator II = 95 / 100)	94.5% (mean of 94.0% and 95.0%)	Very valid
Media (information-technology lecturer)	Ease of navigation (usability); consistency of visual design; layout quality; interactivity	25	92 / 100 (one validator)	92.0%	Very valid

3.1.4 One-to-One and Small-Group Trials

In the one-to-one trial, three students used the E-LKPD independently on their own devices while the researcher observed the clarity of the instructions and the ease of navigation. In the small-group trial, six students used the product at the same time in a lecture-like setting and presented their results to the class. Table 5 summarises the practicality results: both trials fell in the very practical category. The percentages were computed from the summed questionnaire scores: 71 out of a maximum of 75 (3 students × 5 items × 5) in the one-to-one trial and 133 out of 150 (6 students × 5 items × 5) in the small-group trial.

Table 5. Results of the practicality trials

Trial	Students	Items	Percentage	Category	Main findings and revisions
One-to-one	3 (high, medium, low ability)	5	94.67% (71 / 75)	Very practical	Unclear navigation-button instructions and some technical terms; minor revisions to menu layout, background colour, navigation buttons and simpler instruction sentences
Small group	6 (2 high, 2 medium, 2 low)	5	88.67% (133 / 150)	Very practical	Last major revision of design and content: menu structure aligned with the learning trajectory, help button added, text–background contrast improved, and instructions and time allocation clarified; regarded as the final prototype

Observations and interviews in the one-to-one trial showed that students had difficulty with the clarity of the instructions for the navigation buttons and with several technical terms. In response, the menu layout was revised, the instruction sentences were simplified, and the background colours and navigation buttons were redesigned to be more intuitive. In the small-group trial, students discussed actively but needed more time on the worksheets, so interactive operating instructions were added and the time allocation was aligned with actual working time.

Product revision therefore proceeded in three stages. First, after expert review, the revisions sharpened the mathematical concepts and corrected the writing of Arabic terms and script. Second, after the one-to-one trial, the revisions focused on the aesthetics of the background colour and the

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navigation buttons. Third, after the small-group trial, the task instructions in the E-LKPD were clarified so that students would not misinterpret the assignments. The last major revision, based on the small-group evaluation, comprised (1) a refined main-menu structure so that the exploration of concepts follows the learning trajectory more coherently; (2) a help button to prevent confusion when operating the interactive features; and (3) improved contrast between text and background for visual comfort.

3.1.5 Field Test

The field test involved one full class of 27 PBA students, who used the revised E-LKPD in one learning session led by a lecturer, on their own laptops and smartphones; the researchers acted as facilitators and observers. Table 6 reports the post-test results. Twenty-five students (92.59%) reached the mastery criterion, which falls in the very effective category. The two remaining students were interviewed and said that their limited fluency in Arabic made the material somewhat difficult to follow. Field notes and video documentation recorded during the trials also showed a high level of student engagement with the E-LKPD, indicated by students' eagerness to be the first to try the interactive features, interactive discussion among group members without waiting for the lecturer's instructions, and persistence in completing the challenge items, even beyond the break time provided.

Table 6. Field-test results

Statistic	Value
Number of students	27
Mean post-test score (SD)	85.4 (SD = 10.27)
Minimum–maximum score	60–100
Students reaching the mastery criterion (score ≥ 70)	25 (92.59%)
Students not reaching the criterion	2 (7.41%)
Effectiveness score used for classification	92.59% (25 of 27 students)
Category	Very effective

3.1.6 Retrospective Analysis and Preliminary LIT

The retrospective analysis compared the HLT with students' actual learning in the trials. The conjecture that students would build understanding through contextual tasks and visual models was supported: students were able to construct formal notation and bilingual terms from the contextual visual models. However, the conjecture about time allocation deviated from practice: students needed more time in the group-discussion phase because of their high enthusiasm in relating the contextual problems to their everyday experience, which implies that more time should be planned for group discussion. The following design principles are proposed as a preliminary local instructional theory: (1) start from contextual grouping problems with visual models; (2) present Arabic and Indonesian terms side by side with the same visual model; (3) move gradually from

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visual models through bilingual terminology to formal notation; and (4) provide vocabulary and basic-grammar support for students with limited Arabic fluency.

3.2 Discussion

3.2.1 The Process of Developing the Bilingual E-LKPD

The development followed a sequence of linked stages: needs analysis, design, self-evaluation, expert review and multi-level user testing. Beginning with a needs analysis is important because effective language learning requires approaches that take learners' specific needs and characteristics into account (Brown, 2007). The preliminary finding that most students had difficulty understanding abstract material without concrete visualisation is in line with the contrast between Arabic and Indonesian number expressions described by (Syauqillah & Hilmi, 2021) and with the motivation concerns that led (Ginting et al., 2024) to use mind mapping for *'adad ma'dud*. Designing the product in Canva with interactive elements and LiveWorksheets was intended to strengthen interactivity, in line with other contextual electronic worksheets developed for Arabic learning (Abiyyah et al., 2025). Self-evaluation before expert validation was an important step because visual quality and the readability of bilingual text strongly affect users' comfort in operating the product.

Expert validation produced scores of 94.5% (material experts, mean of two validators) and 92.0% (media expert), both in the very valid category. This indicates that the experts judged the content to be accurate in terms of mathematical concepts and Arabic linguistic structure. The bilingual presentation was designed on the constructivist premise that students build new knowledge from prior experience (Piaget, 1972), by letting them relate new Arabic terms to the Indonesian and mathematical schemas they already hold. Expert ratings, however, assess product quality; they do not show whether this mechanism operated in students' learning, which would require analysis of students' reasoning (Section 3.1.6).

The practicality scores of 94.67% (one-to-one) and 88.67% (small group) show that the E-LKPD was easy to use both individually and in a group. The lower score in the small-group trial should be interpreted cautiously: the two trials involved different participants, group sizes and activities, and both scores fall in the same category. Observation suggested that groups with a high heterogeneity of ability tended to spend more time debating conceptual arguments before reaching a collective agreement. This is consistent with (Vygotsky, 1978) social-constructivist view: the negotiation of meaning among students slowed the completion of individual tasks, but appeared to strengthen conceptual understanding by the end of the session, and it may have contributed to the lower small-group score. The result suggests that implementation may also depend on how the product is facilitated in collaborative settings, which future studies should examine by analysing group interaction directly.

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3.2.2 The Effectiveness of the Bilingual E-LKPD on A'dad Materials

In the field test with 27 students, 25 (92.59%) scored at least 70 on the five-item post-test, which falls in the very effective category. This indicates that most students performed well after learning with the E-LKPD. Because the study had no pre-test or comparison group, this result cannot be attributed to the E-LKPD alone: prior knowledge, lecturer support and other instruction may also have contributed. Likewise, the data do not directly show that the product bridged the differences among the Arabic, Indonesian and mathematical number systems; they show that students performed well after using a product designed to support such mapping.

Two students did not reach the mastery criterion, and interviews indicated that their limited fluency in Arabic made the material harder to follow. This suggests that, however well designed, a digital medium needs to be accompanied by support for students' basic language competence, such as vocabulary and grammar scaffolds, and that a bilingual design needs to develop mathematical and language skills in balance.

Students' enthusiasm during the field test, as documented in field notes and video recordings, may indicate that contextual material is relevant and attractive; *a'dad* is closely related to the daily lives of Muslims. However, motivation and learning independence, although stated in the learning objectives, were not measured with an instrument in this study. Overall, the development process produced a bilingual E-LKPD that experts rated as valid, that students rated as practical, and with which students in one class reached a high post-test performance. These findings are promising preliminary evidence rather than conclusive evidence of effectiveness, and the product should be tested further before wider dissemination.

4. Conclusion

This study developed a bilingual (Arabic–Indonesian) E-LKPD on *a'dad* for Arabic Language Education students using design research of the validation-studies type. Experts rated the product as very valid, the one-to-one and small-group trials classified it as very practical, and a field test in one class produced an effectiveness score of 92.59% (very effective) according to the predetermined criterion. These findings provide promising preliminary evidence of the product's quality and of students' achievement after using it in the studied context. The study also yielded preliminary design principles for teaching *a'dad* bilingually: (1) start from contextual grouping problems with visual models; (2) present Arabic and Indonesian terms side by side with the same visual model; (3) move gradually from visual models through bilingual terminology to formal notation; and (4) support students with limited Arabic fluency.

The study has several limitations. It was small-scale and formative; the field test involved one class in one context, used a post-test only without a pre-test or comparison group, and did not measure motivation or learning independence; media validation relied on a single information-technology expert; and no longer-term implementation data were collected. Future research should therefore use a pre-test/post-test or quasi-experimental design, include instruments for motivation and independence, extend trials to other universities to test generalisability, strengthen vocabulary and

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basic-grammar components for students with limited Arabic fluency, and explore artificial-intelligence-based interactive features for personalised learning. In practice, the programme could use the E-LKPD as self-paced enrichment for students with limited Arabic fluency, drawing on its repeatable pronunciation audio, extend the approach to other Arabic topics linked to mathematical concepts, and share it with other lecturers as a model of technology-based material development.

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