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Transforming *Kotak Pesona* Board Game into Web Application for TGT Based Mathematics Practice

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Abstract: Limited research has examined web-based practice media that combine repeated algebra problems, immediate feedback, and Teams Games Tournament (TGT) scoring, and this study aims to develop *Kotak Pesona* (Charming Box) as a TGT-based web game for drill and practice and to examine its feasibility for Grade VII students at Al Hikmah Junior High School Surabaya, Indonesia. A descriptive qualitative development design with the 4-D model (Define, Design, Develop, Disseminate) involved 28 Grade VII students, one material expert, one media expert, and one mathematics teacher from Al Hikmah Junior High School Surabaya, Indonesia. Data from needs, validation, practitioner, and student response questionnaires were analyzed using percentage scores and thematic coding. The needs survey showed that 92.86% of students valued immediate feedback and a new practice game, which led to a game board of 24 small boxes and six large boxes with a point system, while the material expert, media expert, and practitioner gave feasibility scores of 87.50%, 97.50%, and 93.75% (mean 93.27%, very feasible), respectively, and 26 responding students reached a mean agreement of 95.60%. Seven aspects scoring 3 pointed to minor refinements in answer keys, item wording, replay options, team roles, and onboarding, and future research should test learning outcomes with controlled designs. In conclusion, *Kotak Pesona* is very feasible as TGT-based drill and practice media for Grade VII algebra and is ready for wider classroom trials after minor refinements.

Keywords: *Kotak Pesona*; Educational Game; Teams Games Tournament; Drill And Practice; Media Feasibility.

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INTRODUCTION

Algebra is widely treated as the first major gateway to abstract mathematical reasoning in junior high school, because it requires students to read symbols, combine terms, and produce equivalent forms. According to Larbi (2025), Grade 8 students showed identifiable performance levels and difficulties when simplifying algebraic expressions. Research by Osei and Agyei (2024) found that algebra difficulties among Ghanaian junior high school learners persisted during the implementation of a standards-based mathematics curriculum. In a related study, Osei and Agyei (2023) examined the algebra teaching knowledge and difficulties of in-field and out-of-field junior high school mathematics teachers, which positions practice media as a practical support for teachers who address these difficulties.

Mastery of algebraic procedures depends on repeated practice that is accompanied by information about correctness. According to Agarwal et al. (2021), a systematic review of 50 classroom experiments showed that retrieval practice consistently benefited student learning across school settings. Recent evidence from Yang et al. (2021) indicates that classroom quizzing raised achievement to a medium extent across 222 studies, and that the provision of corrective feedback and the number of test repetitions moderated the effect. In a meta-analytic synthesis, Sotola and Crede (2021) examined the relationship between frequent low-stakes testing and class performance, which frames short and repeated practice rounds as a relevant design feature for practice media.

Digital practice environments can deliver feedback at the moment of response, yet the evidence on its effects shows variation. Previous studies have reported that immediate feedback and re-attempts in online problem sets supported response accuracy among middle school students, although the effect on standardized achievement was not always large (Smith et al., 2025). Research by Rezat (2021) examined automated feedback from a digital mathematics textbook and its role in primary students' conceptual development, and Jablonski (2024) analyzed how digital feedback shapes verification and elaboration in outdoor mathematics tasks. Recent evidence from Anwar et al. (2025) indicates that feedback orientation acts as a mediator among feedback, achievement motivation, and achievement in mathematics, so a practice game needs a feedback step that students can interpret and use.

Digital game-based learning has attracted sustained attention as a way to organize practice around goals, rules, and scoring. According to Hussein et al. (2022), a systematic review of K-12 mathematics education described digital game-based learning as a promising method for promoting students' interest and motivation, and Hui and Mahmud (2023) reported through a review of 28 open-access articles that game-based learning positively influenced the cognitive and affective domains of mathematics learners. A meta-analysis by Barz et al. (2024) found a significant medium effect of digital game-based learning on overall learning ($g = .54$) and a small effect on affective-motivational outcomes ($g = .32$) in school contexts. Evidence from Fadda et al. (2022) indicates that digital games had a significant overall effect on K-12 students' motivation in mathematics, with short interventions showing the highest effects.

Studies on algebra learning with digital games, and on competition within such games, provide closer evidence for the present context. Research by Decker-Woodrow et al. (2023) found that Grade 7 students who used two game-based applications, From Here to There and DragonBox 12+, obtained higher algebra posttest scores than an active control group, whereas an immediate feedback condition did not differ significantly from the control. According to Chan et al. (2023), seventh graders who played these two games improved and maintained gains in conceptual knowledge, while gains in procedural knowledge and procedural flexibility were not sustained at posttest. In studies of competition and collaboration, Wang and Huang (2023) developed a question bank practice game with intergroup competition and intragroup collaboration, and Chen and Tu (2021) examined the structure of competition in digital game-based learning among junior high school students in relation to learning motivation and performance.

Teams Games Tournament (TGT) is a cooperative learning model that places students in teams, uses academic games, and closes with a tournament, and it offers a ready structure for practice that is both social and competitive. Research by Capinding (2021) examined the effect of TGT on the mathematics achievement and class motivation of Grade 8 students. A meta-analysis by Ridwan et al. (2022) of 22 studies indicated that cooperative learning had a moderate but significant effect on vocational high school students' mathematics learning outcomes, and Talkhan et al. (2025) reported positive effects of cooperative learning on primary students' mathematics achievement across 30 studies. These findings show that team-based structures are associated with favorable mathematics outcomes across levels, although the studies differ in context and design.

A preliminary study conducted on June 2026 in a junior high school in Surabaya, Indonesia, surveyed 28 Grade VII students on their readiness for mathematics practice. The survey showed that 82.14% of students agreed that repeated drilling strengthens formula recall and understanding, and 92.86% liked knowing at once whether an answer was correct. Half of the students (50.00%) felt bored or tired when working through printed worksheets, and 78.57% felt more enthusiastic when practice took the form of a group game. In addition, 92.86% agreed with introducing a new practice game for individual or group use, which indicates a local need for a practice medium that combines repetition, immediate feedback, and group play.

Existing studies have primarily focused on game-based algebra applications evaluated through randomized trials, as in Decker-Woodrow et al. (2023) and Chan et al. (2023), and on TGT as an instructional model linked to motivation and achievement, as in Capinding (2021). Research remains limited regarding how a practice game that merges drill content, immediate answer feedback, and TGT scoring rules can be developed for Grade VII algebra from an existing physical board game. Less attention has been directed toward how experts, a practitioner, and students judge the feasibility of such a product before its effectiveness is tested. This aspect remains underexplored, particularly within junior high school classrooms where algebra difficulties persist, as documented by Larbi (2025).

This study addresses an underexplored aspect of algebra practice by developing and evaluating *Kotak Pesona* (Charming Box), a web application that transforms a physical board game into a TGT-based digital game for drill and practice. This study extends previous research by examining a 30-box game structure with TGT scoring rules and immediate answer reveal, using the 4-D development model within a Grade VII junior high school context. The aim of this study is to describe how the game was developed from coded student needs and to examine whether it is feasible as drill and practice media according to material expert, media expert, practitioner, and student judgments. The contribution claimed here is the combination of a TGT scoring mechanism, an algebra question bank sequenced from vocabulary to division, and a multi-perspective feasibility profile, and the study stops at feasibility without testing learning outcomes.

To achieve this aim, the study is guided by two research questions. 1) How was *Kotak Pesona* developed through the 4-D model as a TGT-based web game for algebra drill and practice among Grade VII students? 2) How feasible is *Kotak Pesona* as drill and practice media according to the judgments of a material expert, a media expert, a mathematics teacher, and students? The answers are expected to give teachers and developers a documented design path and an evidence base for deciding whether the product is ready for wider classroom trials.

METHOD

Research Design and Setting

This study employed a descriptive qualitative approach with a development research orientation to produce and evaluate *Kotak Pesona* (Charming Box), a web-based educational game built on the Teams Games Tournament (TGT) model for drill and practice. The 4-D model of Thiagarajan et al. (1974), which consists of Define, Design, Develop, and Disseminate, structured the process. The study took place in a junior high school in Surabaya, Indonesia, in September and October 2026. The design focused on describing the development process and appraising feasibility against media indicators, so effectiveness testing with a control group fell outside its scope.

Before the research procedures are described in detail, Figure 1 shows how the four stages of the 4-D model were sequenced and which activity and data source belonged to each stage. The figure links the needs questionnaire of 28 students to the Define stage, the board of 30 boxes and the scoring rules to the Design stage, the validation by experts and a practitioner to the Develop stage, and the limited trial to the Disseminate stage. It is placed in the Method section so that every table in the Results section can be traced to one stage of the process. Readers can therefore use the figure as a map when they move through the findings.

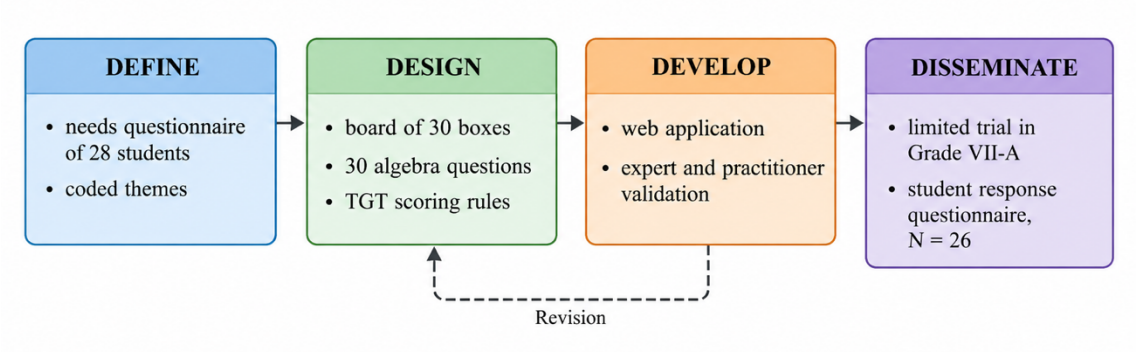


Figure 1. Development Flow of *Kotak Pesona* Using the 4-D Model

Participants and Data Sources

The participants were 28 Grade VII-A students at Al Hikmah Junior High School Surabaya, Indonesia, with mixed academic abilities, who completed the preliminary needs questionnaire on June 2026. After the limited trial, 26 of these students returned the student response questionnaire, representing a response rate of 92.86%. The expert panel consisted of one university lecturer as a material expert with a master's degree in mathematics education and more than five years of teaching experience, one university lecturer specializing in educational technology as a media expert, and one mathematics teacher from Al Hikmah Junior High School Surabaya as a practitioner. Table 1 summarizes the participant groups and the data provided by each group.

Table 1. Participants and Data Provided

Participant group	n	Characteristics	Data provided
Students (needs analysis)	28	Grade VII-A students at Al Hikmah Junior High School Surabaya, Indonesia, with mixed academic abilities	Needs questionnaire (8 statements), June 2026
Students (limited trial)	26	Students from the same class at Al Hikmah Junior High School Surabaya; response rate of 92.86%	Response questionnaire (14 statements)
Material expert	1	University lecturer, master's degree in mathematics education, more than 5 years of teaching experience	Material validation sheet (8 items)
Media expert	1	University lecturer, educational technology specialist	Media validation sheet (10 items)
Practitioner	1	Mathematics teacher of the research school	Practitioner assessment sheet (8 items)

Instruments

Seven instruments were prepared, namely an eight-statement needs questionnaire, a material validation sheet (8 items), a media validation sheet (10 items), a practitioner assessment sheet (8 items), a 14-statement student response questionnaire, an interview guide, and a field-note and documentation sheet. All questionnaires and validation sheets used four response levels, with Strongly Agree scored 4, Agree 3, Disagree 2, and

Strongly Disagree 1 for student statements and a scale of 1 to 4 for validation items. The results reported in this article draw on the questionnaires and validation sheets, while the interview guide and field notes supported the description of the development process. Table 2 links each data source to its instrument, analysis technique, and research question.

Table 2. Research Questions, Data Sources, Instruments, and Analysis

Component	Source	Instrument	Analysis	Research question
Student needs	28 students	Needs questionnaire (8 statements)	Percentage of agreement and thematic coding	RQ1
Product development	Development documents	Field notes and documentation sheet	Data reduction, display, and conclusion drawing	
Material feasibility	1 material expert	Validation sheet (8 items, scale 1-4)	Percentage score	RQ2
Media feasibility	1 media expert	Validation sheet (10 items, scale 1-4)	Percentage score	
Practicality	1 mathematics teacher	Practitioner sheet (8 items, scale 1-4)	Percentage score	
User response	26 students	Response questionnaire (14 statements)	Percentage of agreement and weighted score	

Procedure, Data Analysis, and Research Ethics

The Define stage identified student needs through the questionnaire and discussions with the mathematics teacher. The Design stage arranged the interface, the question bank, and the TGT scoring rules, and the Develop stage built the application and collected expert validation. The Disseminate stage was carried out in a limited form through a trial in Grade VII-A. Student responses were collected after this trial through the 14-statement questionnaire.

Qualitative data on the development process were analyzed through data reduction, data display, and conclusion drawing. Feasibility data were analyzed with the formula $P = (\Sigma x / \Sigma xi) \times 100\%$, where Σx is the obtained score and Σxi is the maximum score. Student responses were also reported as the combined percentage of Strongly Agree and Agree and as a weighted score in which Strongly Agree equals 4, Agree equals 3, Disagree equals 2, and Strongly Disagree equals 1, expressed as a percentage of the maximum possible score. Table 3 gives the interpretation criteria and Figure 2 shows the analysis workflow.

Table 3. Feasibility Criteria

Percentage score	Category
81-100%	Very feasible
61-80%	Feasible
41-60%	Fairly feasible
≤ 40%	Not feasible

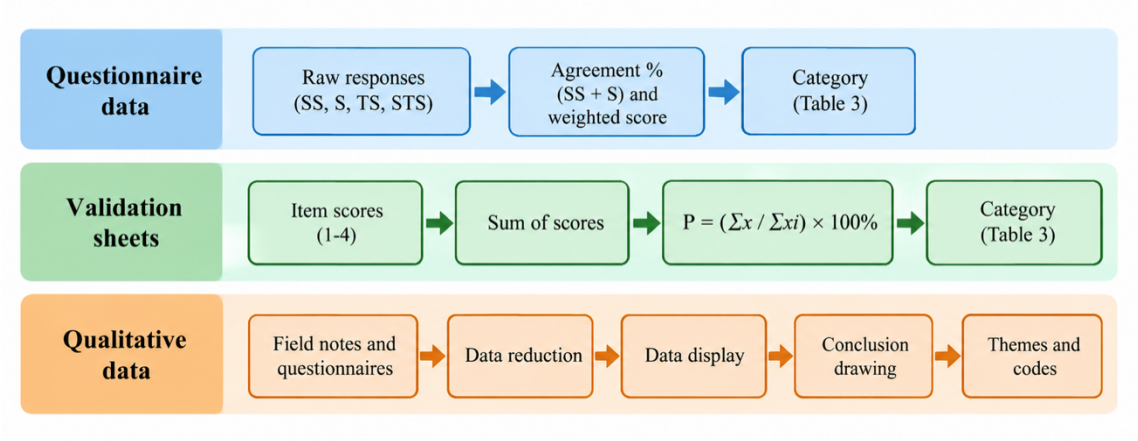


Figure 2. Data Analysis Workflow

Table 3 presents the criteria used to interpret the feasibility percentages, while Figure 2 summarizes the data analysis procedures. The quantitative data were converted into percentage scores and interpreted according to the specified feasibility categories. Qualitative data were processed through data reduction, data display, and conclusion drawing.

Trustworthiness was supported by technique triangulation and expert judgment. Ethical conduct was ensured through an official research permit from the school, informed consent from the teacher and students, and anonymity of student identities. Only aggregated percentages are reported, so no individual student can be identified from the tables. These safeguards covered the needs survey, the expert validation, and the limited trial.

RESULTS

Define: Student Learning Needs

The preliminary study on June 2026 involved all 28 Grade VII-A students and covered eight statements grouped into three themes, namely drill and practice experience, autonomy and learning activity, and variation of learning media. Agreement was highest for immediate feedback and for a new practice game (92.86% each), followed by independent repetition of exercises (85.71%) and the need for drilling (82.14%). Group-based enthusiasm and preference for discussion each reached 78.57%, physical teaching aids reached 67.86%, and boredom with printed worksheets reached 50.00%, which gives an overall mean agreement of 78.57%. Table 4 reports the response distribution of each statement and Figure 3 displays the resulting agreement profile.

Table 4. Results of the Preliminary Student Readiness Questionnaire (N = 28)

Theme	Statement	SS (%)	S (%)	TS (%)	STS (%)	Agree (SS+S, %)
A. Drill and practice experience	A1. I need to work on problems repeatedly (drill) so that my formula recall and understanding grow stronger.	39.29	42.86	14.29	3.57	82.14
	A2. I quickly feel bored or tired when I must work through many practice problems on worksheets or printed books.	10.71	39.29	42.86	7.14	50.00
	A3. I like knowing right away whether my answer is correct or incorrect after finishing a problem.	53.57	39.29	3.57	3.57	92.86
B. Autonomy and learning activity	B1. I feel more enthusiastic about learning when practice problems are designed as a group game.	57.14	21.43	14.29	7.14	78.57
	B2. When I do not yet understand the material, I try to find ways or repeat practice by myself at home.	32.14	53.57	7.14	7.14	85.71
	B3. I prefer learning mathematics while discussing or working with friends.	50.00	28.57	14.29	7.14	78.57
C. Variation of learning media	C1. Learning with teaching aids or physical games helps me understand more easily.	42.86	25.00	21.43	10.71	67.86
	C2. I agree with a new game for mathematics practice in class, either individually or in groups.	64.29	28.57	0.00	7.14	92.86

Note. SS = Strongly Agree; S = Agree; TS = Disagree; STS = Strongly Disagree.

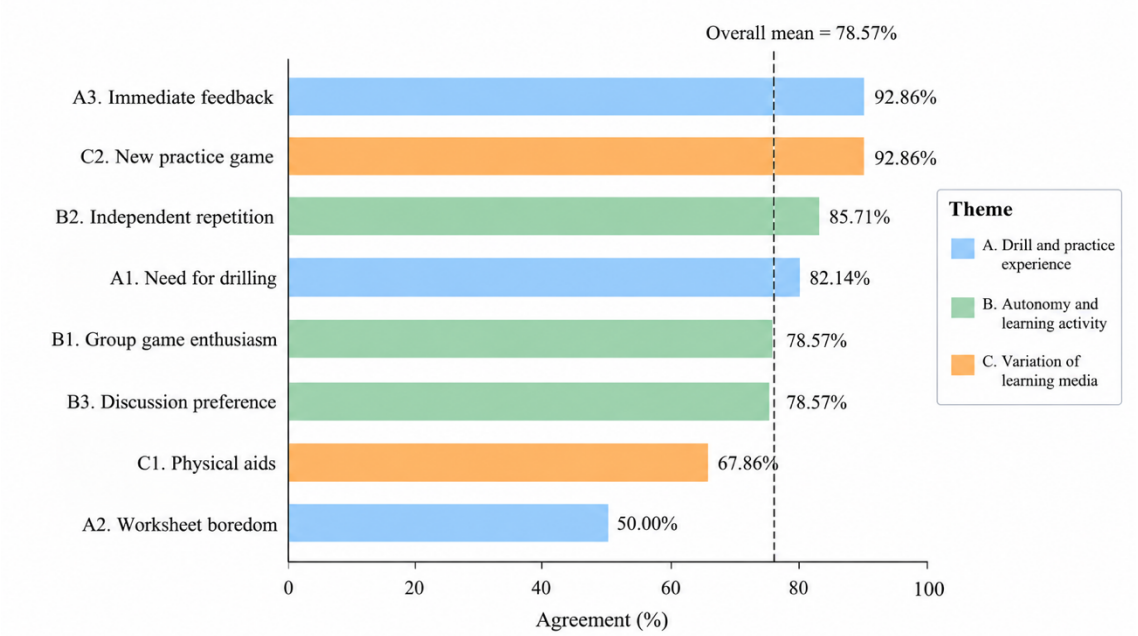


Figure 3. Agreement per Statement in the Preliminary Questionnaire (N = 28)

The results indicate that students particularly valued immediate feedback and opportunities to use a new mathematics practice game. Although most students supported repeated practice and group-based activities, responses concerning physical teaching aids and boredom with printed worksheets showed greater variation. These findings provided the basis for identifying the main design requirements of *Kotak Pesona*.

Three themes were coded from these responses, and each code was assigned a design decision. The first theme, repeated practice with immediate feedback (codes REP, FDB, BOR), shows that students value repetition and instant verification, and the even split on worksheet boredom indicates that printed practice suits only half of the class. The second theme, autonomy and collaboration (codes AUT, COL, DIS), shows that 85.71% of students repeat exercises by themselves and 78.57% prefer group games and discussion, which supports a team format in which each member remains accountable for answers. The third theme, media variation (codes PHY, NEW), shows that acceptance of a new practice game (92.86%) was higher than the endorsement of physical aids (67.86%), and Table 5 summarizes the coding together with the design decision attached to each code.

Table 5. Thematic Coding of the Preliminary Study and Design Implications

Theme	Code	Evidence	Interpretation	Design decision
Repeated practice with immediate feedback	REP (need for repetition)	82.14% agreement	Students link repetition to formula recall and understanding	Question bank of 30 items for repeated rounds
	FDB (immediate feedback)	92.86% agreement	Instant verification is a strong expectation	Answer reveal on each question screen

	BOR (worksheet fatigue)	50.00% agreement	Printed practice suits half of the class	Replace the worksheet format with a game board
Autonomy and collaboration	AUT (self-initiated repetition)	85.71% agreement	Students already repeat practice by themselves	Questions that can also be replayed individually
	COL (group game enthusiasm)	78.57% agreement	Group games raise enthusiasm	Team turns and team scores
	DIS (discussion preference)	78.57% agreement	Peers support understanding	Discussion before answering
Media variation	PHY (physical aids)	67.86% agreement	Physical aids help most students	Board metaphor with numbered boxes
	NEW (new game)	92.86% agreement	A new game is widely accepted	Digital game with TGT rules

Design: Game Architecture and Question Bank

The Design stage translated the coded needs into a game board of 30 numbered boxes, consisting of 24 small green boxes (numbers 1 to 24) and six large red boxes (numbers 25 to 30), displayed on one main screen as shown in Figure 4. Selecting a box opens a single-question screen with the question text, the answer revealed after the response, and a return button to the board, and the application is available as a web page at https://kotakpesona.base44.app/. Teams take turns choosing boxes, small-box questions can be thrown to another participant, and large-box questions must be answered by the team that selected them. Figure 4 shows the main board interface and Table 6 maps each TGT component to the corresponding feature and scoring rule.

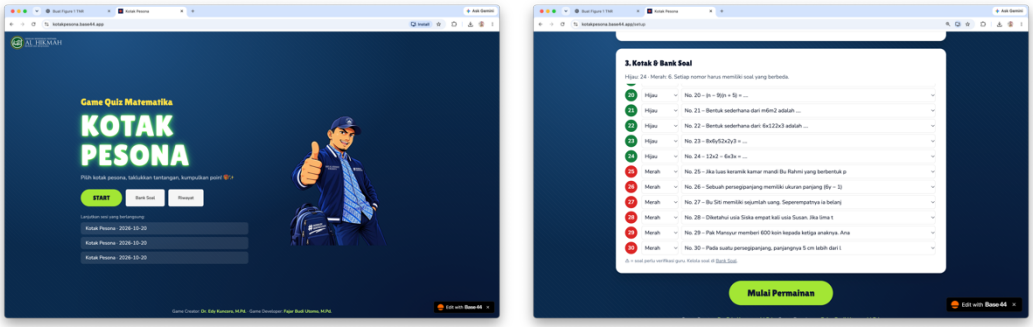


Figure 4. Main Board Interface of *Kotak Pesona* with 24 Small Boxes and Six Large Boxes

Table 6. Mapping of TGT Components to *Kotak Pesona* Features and Scoring Rules

TGT component	Feature in *Kotak Pesona*	Rule or scoring
Teams	Students form groups that take turns selecting boxes and discuss before answering	Each group holds an accumulated score
Games	30 numbered boxes: 24 small (green), 6 large (red)	Each box opens one question with answer reveal
Small box, correct answer	Question answered by the selecting team	+100 points
Small box, incorrect answer	Question answered by the selecting team	-80 points
Throw of a small-box question	Question passed to a randomly chosen other participant	Thrower +20 points; receiver must answer: correct +100, incorrect -80
Large box	Mandatory answer, no throwing allowed	Correct +200 points; incorrect -200 points
Tournament	Accumulated points across rounds	Teams are ranked by total score

The game architecture integrates team-based participation, question selection, and cumulative scoring into a single digital board. The distinction between small and large boxes introduces different levels of scoring risk, while the throwing mechanism allows other participants to answer selected questions. These rules operationalize the team, game, and tournament components of TGT within the web application.

The question bank contains 30 algebra items arranged by topic, with the item number matching the box number. The items begin with the elements of algebraic forms (items 1 to 3), continue with addition and simplification (items 4 to 9), subtraction (items 10 to 12 and 14), and multiplication (items 15 to 20), and then move to contextual problems on perimeter, coins, money, age, and area (items 13 and 21 to 25) and algebraic division (items 26 to 30). The six large boxes hold item 25, which asks for the width of a rectangular tile from an area expression, and items 26 to 30 on algebraic division, so the highest symbolic demand sits under the highest stakes. Table 7 shows the distribution of the 30 questions by topic and box type.

Table 7. Distribution of the Question Bank by Topic and Box Type

Topic	Item (box) numbers	Number of items	Box type
Elements of algebraic forms (coefficient, constant, variable)	1-3	3	Small
Addition and simplification	4-9	6	Small
Subtraction	10-12, 14	4	Small
Multiplication	15-20	6	Small
Contextual problems (perimeter, coins, money, age)	13, 21-24	5	Small
Contextual problem (area and width)	25	1	Large
Algebraic division	26-30	5	Large
Total	1-30	30	24 small, 6 large

The question bank follows a progression from basic algebraic terminology to arithmetic operations and contextual applications. The allocation of more demanding items to the large boxes introduces greater scoring stakes for questions involving area and algebraic division. This arrangement connects the mathematical content with the game's scoring structure while providing opportunities for repeated practice across different algebra topics.

Develop: Expert and Practitioner Validation

The material expert awarded 28 of 32 points (87.50%), the media expert awarded 39 of 40 points (97.50%), and the mathematics teacher awarded 30 of 32 points (93.75%), which together give 97 of 104 points and a mean of 93.27%. All three assessors placed the product in the very feasible category, and 19 of the 26 assessed aspects received the maximum score of 4. Table 8 summarizes the validation scores of the three assessors. Figure 5 visualizes these percentages against the very feasible threshold.

Table 8. Results of Expert and Practitioner Validation

Assessor	Items	Obtained score	Maximum score	Percentage	Category
Material expert	8	28	32	87.50%	Very feasible
Media expert	10	39	40	97.50%	Very feasible
Practitioner (mathematics teacher)	8	30	32	93.75%	Very feasible
Total	26	97	104	93.27%	Very feasible

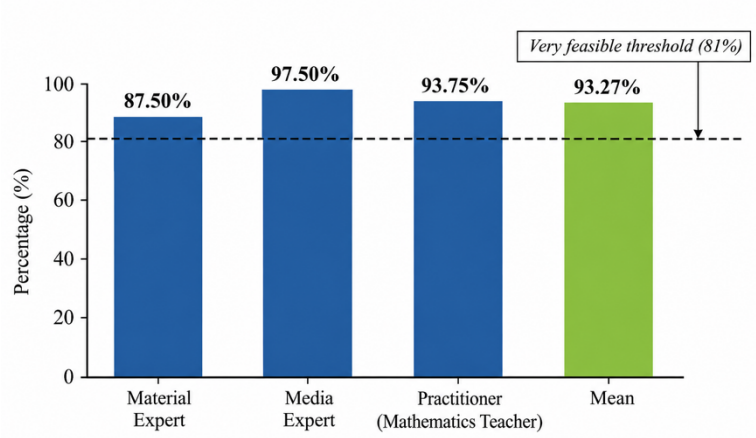


Figure 5. Feasibility Percentage by Assessor

All three assessors rated Kotak Pesona within the very feasible category, with scores exceeding the established threshold of 81%. The media expert provided the highest rating (97.50%), followed by the practitioner (93.75%) and the material expert (87.50%).

These results indicate favorable assessments across content accuracy, media design, and classroom practicality, although several aspects still require minor refinement.

Seven aspects received a score of 3, and each was assigned a revision code to guide follow-up refinement. The material expert gave a 3 to material correctness, answer key accuracy, item clarity, and alignment with the practice purpose, which points to a careful check of keys and item wording. The media expert gave a 3 to functional suitability for repeated practice, and the practitioner gave a 3 to group activity support and ease of preparation by teachers, which indicates that repeated rounds and classroom set-up deserve attention. Table 9 lists the aspects that scored 3 and the revision codes assigned to them.

Table 9. Aspects Scoring 3 and Revision Codes

Assessor	Aspect	Score	Code	Follow-up refinement
Material expert	Correctness of material	3	MAT	Re-check mathematical statements in each item
Material expert	Accuracy of answers	3	KEY	Re-check answer keys and solution steps
Material expert	Clarity of questions	3	CLR	Simplify wording and remove ambiguity
Material expert	Alignment with the practice purpose	3	OBJ	Balance items across the practice goals
Media expert	Functional suitability for repeated practice	3	FNC	Strengthen replay options for repeated rounds
Practitioner	Support for group activity	3	GRP	Add clearer team roles in the instructions
Practitioner	Ease of preparation by teachers	3	PRC	Provide a short set-up guide for teachers

Although the overall feasibility scores were high, seven assessment aspects received a score of 3 rather than the maximum score of 4. These aspects concerned mathematical accuracy, answer keys, question clarity, alignment with practice objectives, replay functionality, group activity support, and teacher preparation. The corresponding revision recommendations were used to identify specific improvements before wider classroom implementation.

Disseminate (Limited): Student Responses

Twenty-six of the 28 students completed the response questionnaire after the limited trial, and the 14 statements produced a mean agreement of 95.60% and a mean weighted score of 89.97%. Interest in practice (statement 9) reached 100% agreement, while the highest weighted scores of 93.27% appeared for team practice (statement 11), practicality (statement 13), and overall use as practice media (statement 14). The lowest weighted scores of 86.54% appeared for following the game flow (statement 4) and practicing again through available activities (statement 6), although both still reached 96.15% agreement. Table 10 presents the response distribution for each of the 14 statements, and

disagreement was limited to one or two students per statement, namely 3.85% (one student) or 7.69% (two students).

Table 10. Student Responses to *Kotak Pesona* (N = 26)

No	Statement	SS (%)	S (%)	TS (%)	STS (%)	Agree (%)	Weighted score (%)
1	The appearance of *Kotak Pesona* is easy for me to understand.	65.38	30.77	0.00	3.85	96.15	89.42
2	The instructions for using *Kotak Pesona* are clear.	57.69	38.46	3.85	0.00	96.15	88.46
3	I can use the main features according to the instructions.	65.38	26.92	7.69	0.00	92.31	89.42
4	I can follow the flow of the game without significant confusion.	50.00	46.15	3.85	0.00	96.15	86.54
5	*Kotak Pesona* gives me a chance to practice mathematics problems.	69.23	26.92	3.85	0.00	96.15	91.35
6	I can practice again through the activities available.	50.00	46.15	3.85	0.00	96.15	86.54
7	I can find out the result of my answer through the available feedback.	57.69	38.46	3.85	0.00	96.15	88.46
8	The feedback helps me identify which parts of my answers need improvement.	61.54	34.62	3.85	0.00	96.15	89.43
9	I am interested in doing mathematics practice through *Kotak Pesona*.	53.85	46.15	0.00	0.00	100.00	88.46
10	The game activities make mathematics practice feel more interesting.	69.23	26.92	3.85	0.00	96.15	91.35
11	*Kotak Pesona* supports mathematics practice together with a team.	80.77	11.54	7.69	0.00	92.31	93.27
12	The game and tournament mechanism helps me follow group practice according to the rules.	65.38	30.77	3.85	0.00	96.15	90.38
13	*Kotak Pesona* is practical for mathematics practice.	80.77	11.54	7.69	0.00	92.31	93.27
14	Overall, *Kotak Pesona* can be used as mathematics practice media.	76.92	19.23	3.85	0.00	96.15	93.27
	Mean	**64.56**	**31.04**	**4.12**	**0.27**	**95.60**	**89.97**

Student responses indicated favorable perceptions of Kotak Pesona across usability, practice opportunities, feedback, interest, and team-based activities. Agreement ranged from 92.31% to 100.00%, while weighted scores ranged from 86.54% to 93.27%.

The differences between agreement and weighted scores suggest that, although most students responded positively, the intensity of their responses varied across application features.

The six response dimensions were coded to interpret the pattern, and interest and motivation (code MOT) had the highest agreement (98.08%). Practice opportunity (PRA) and feedback (FDB) each reached 96.15%, and team practice (TEA) and practicality with overall use (PRC) reached 94.23% agreement with weighted scores of 91.83% and 93.27%. Interface and usability (USA) reached 95.19% agreement with the lowest weighted score of 88.46%, which points to onboarding and navigation as the area with the most room for improvement. Table 11 summarizes the six dimensions with their codes and interpretation, and Figure 6 shows the mean agreement by dimension.

Table 11. Student Response by Dimension

Dimension	Code	Statements	Mean agreement (%)	Mean weighted score (%)	Category	Interpretation
Interface and usability	USA	1-4	95.19	88.46	Very feasible	Display is clear, with room to improve onboarding
Practice opportunity	PRA	5-6	96.15	88.95	Very feasible	Repeated practice is recognized
Feedback	FDB	7-8	96.15	88.95	Very feasible	Answer checking and error spotting are useful
Interest and motivation	MOT	9-10	98.08	89.91	Very feasible	Game format raises interest
Team practice	TEA	11-12	94.23	91.83	Very feasible	Team rules support group practice
Practicality and overall use	PRC	13-14	94.23	93.27	Very feasible	Product is practical as practice media
Overall		**1-14**	**95.60**	**89.97**	**Very feasible**	

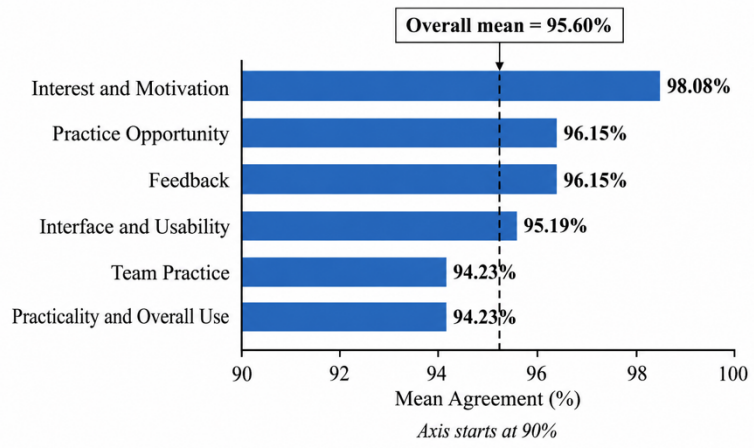


Figure 6. Mean Student Agreement by Dimension

The six response dimensions were all categorized as very feasible. Interest and motivation achieved the highest mean agreement (98.08%), whereas practicality and overall use obtained the highest weighted score (93.27%). Interface and usability recorded the lowest weighted score (88.46%), indicating that navigation and initial user orientation remain areas for improvement.

Synthesis of Findings

For the first research question, the development path ran from coded student needs (repetition, immediate feedback, group play, and new media) to a 30-box web game whose rules combine team turns, throwing, and large-box stakes with a question bank sequenced from algebraic vocabulary to division. For the second research question, the three assessors and the student respondents all placed *Kotak Pesona* in the very feasible category, with percentages of 87.50% for material, 97.50% for media, 93.75% for practicality, and 95.60% for student agreement. The aspects scoring 3 and the lower weighted scores for game flow and re-practice converge on the same refinement areas, namely answer keys and wording, replay options, team roles, and onboarding. Table 12 and Figure 7 integrate these findings for both research questions.

Table 12. Integration of Findings by Research Question

Research question	Evidence	Key result	Implication
RQ1	Needs questionnaire (N = 28)	REP 82.14%, FDB 92.86%, COL 78.57%, NEW 92.86%	Four needs mapped to question bank, answer reveal, team turns, and digital game format
RQ1	Design stage	30 boxes (24 small, 6 large), 30 items, TGT scoring	Mechanism and content traceable to coded needs
RQ2	Material expert	87.50%, very feasible	Re-check answer keys and item wording
RQ2	Media expert	97.50%, very feasible	Strengthen replay options
RQ2	Practitioner	93.75%, very feasible	Clarify team roles and add a teacher set-up guide
RQ2	Student responses (N = 26)	95.60% agreement, 89.97% weighted score	Improve onboarding and game flow

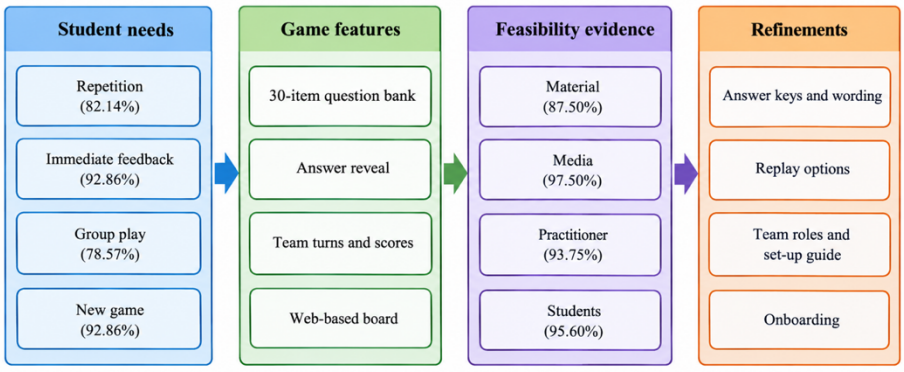


Figure 7. From Student Needs to Game Features and Feasibility Evidence

DISCUSSION

Learning Needs and Drill Design

The preliminary survey showed that 82.14% of students endorsed repeated drilling and 92.86% valued immediate answer checking, and these needs shaped a 30-item question bank with an answer reveal on every question screen because each coded need was mapped to a feature before the design was drafted. According to Yang et al. (2021), classroom quizzing raised student achievement to a medium extent across 222 studies, and the provision of corrective feedback and the number of test repetitions moderated the effect, which is consistent with attaching an answer reveal to each repeated item. Different patterns have been reported for feedback in digital problem sets, since Decker-Woodrow et al. (2023) found no significant posttest difference for an immediate feedback condition while two game-based conditions showed higher scores, and Smith et al. (2025) reported accuracy benefits with effects on standardized achievement that were not always large, so these variations may be associated with differences in task format, duration, and outcome measures. The present findings should be interpreted as evidence that students expect immediate verification and find the feedback feature acceptable, and since Liao et al. (2024) reviewed feedback direction, form, and technique type in smart learning environments, future versions of *Kotak Pesona* can examine whether explanatory feedback adds value to the answer reveal.

Game Mechanism and TGT Structure

The Design stage produced a board of 24 small and six large boxes with +100/-80, +20 throw, and +200/-200 scoring that places TGT teams, games, and tournament accumulation in one mechanism, a structure that resulted from mapping each TGT component to a rule of the earlier physical board and keeping the point values in the web version. Research by Wang and Huang (2023) found that perceived competition was a stronger factor behind learning performance than perceived collaboration and that competition promoted collaboration in a question bank practice game with intergroup competition and intragroup collaboration, which matches the combination of team cooperation and score competition built into *Kotak Pesona*. According to Ratinho et al. (2026), gamified designs appear promising for motivation and engagement in mathematics when competition is balanced with mastery and cooperation, and Capinding (2021) examined TGT as an instructional strategy for Grade 8 students, so the web format adds an automated board and answer reveal to an established cooperative structure. These comparisons suggest that the mechanism is coherent as a TGT-based practice structure, and because Wang and Huang (2023) described competition as capable of causing psychological stress, teachers should monitor the effect of the penalty values of -80 and -200 and adjust them to the class.

Question Bank and Algebra Progression

The question bank of 30 items moves from the elements of algebraic forms to addition, subtraction, multiplication, contextual problems, and division, and the six highest-stakes boxes hold the most symbolically demanding items, an arrangement that follows a

progression from vocabulary to operations to application. According to Larbi (2025), Grade 8 students showed difficulties when simplifying algebraic expressions, and Osei and Agyei (2024) reported that algebra difficulties among junior high school learners persisted under a standards-based curriculum, which gives a rationale for placing addition, subtraction, and multiplication items in a repeated practice format. Evidence on how gains develop differs by knowledge type, since Chan et al. (2023) found that conceptual gains were maintained among seventh graders who played two algebra games while gains in procedural knowledge and flexibility were not sustained at posttest, and Smith et al. (2022) examined how algebra worked example presentations affect student learning. These patterns suggest that procedural fluency in *Kotak Pesona* may need repeated rounds and visible solution steps, so the replay options flagged by the media expert and a worked solution in each answer reveal are practical priorities for the next version.

Expert and Practitioner Feasibility

The three assessors rated the product at 87.50%, 97.50%, and 93.75%, which gives a mean of 93.27% in the very feasible category, and these scores came from structured validation sheets completed after the assessors reviewed the application against content, media, and classroom practicality indicators. According to Hussein et al. (2022), a systematic review of K-12 mathematics education described digital game-based learning as a promising method for promoting students' interest and motivation, and the high feasibility judgments here are consistent with that direction. Evidence on achievement is more varied, since Anggoro et al. (2025) reported a small overall effect of game-based learning on mathematics higher order thinking skills ($g = .134$) with effects moderated by educational level and intervention duration, and Naccache et al. (2025) implemented a game-based intervention to enhance mathematics achievement in Qatar, which illustrates the kind of intervention study that can follow feasibility evidence. Feasibility should therefore be read as readiness for classroom trial, the seven aspects scoring 3 define the refinements that should precede a controlled study, and learning gains remain a question for later research.

Student Responses and Engagement

Twenty-six students gave a mean agreement of 95.60% and a mean weighted score of 89.97%, with the highest dimension on interest and motivation (98.08%) and 100% agreement on interest in practice, a pattern that is consistent with a game format whose points, turns, and tournament ranking make repeated problems feel more interesting. Recent evidence from Fadda et al. (2022) indicates that digital games had a significant overall effect on K-12 students' motivation in mathematics, and Yu et al. (2021) examined both positive and negative effects of educational games on motivation and engagement. Zhang and Yu (2022) compared gamification and game-based learning in terms of achievement and motivation, so the high agreement reported here should be interpreted as perceived interest after a limited trial and should be compared with effect sizes from controlled studies only with caution. The lower weighted scores for game flow

and re-practice point to onboarding as a refinement target, and Çömert and Samur (2026) discussed pretraining, feedback, and segmenting principles in educational game design, which offers a framework for a short orientation before the first round.

Team Practice and Instructional Implications

Team practice statements reached 92.31% and 96.15% agreement and the dimension earned a weighted score of 91.83%, which follows the preliminary finding that 78.57% of students preferred group games and discussion because the same preference was carried into the team rules and later checked in the response questionnaire. According to Ulum and Küçükaydın (2024), mathematics achievement, academic motivation, and social context interact among adolescents, and Lahdenperä et al. (2022) reported that student-centred learning environments helped undergraduate students apply regulated learning in mathematics, so a team format may support both the social and the self-regulated aspects of practice. In a meta-analysis of game-based learning outcomes in mathematics education, Nguyen (2026) provided a wider base for planning outcome testing, although the present study did not measure learning outcomes and the populations differ across studies. For instruction, the team dimension supports the use of *Kotak Pesona* as a cooperative algebra practice activity after concept instruction, with scoring rules and team roles explained before the first round and a short set-up guide prepared for teachers.

Limitations

This study involved one class, one material expert, one media expert, and one practitioner, so the findings describe feasibility in a specific school context and should be generalized with caution. Student responses are self-reported perceptions, and the study did not include a control group or a test of learning outcomes. The analyses reported here draw on questionnaires and validation sheets, a systematic analysis of observation records on TGT implementation was not included, the dissemination stage was limited to one trial in Grade VII-A, and the question bank covers algebra only. Future studies can address these limits with larger samples, several classes, additional topics, and measures of achievement and retention.

CONCLUSION

Kotak Pesona was developed through the 4-D model as a TGT-based web game that places repeated algebra practice, immediate answer checking, and team competition in one application. The path from the needs survey of 28 students to a 30-box board with a 30-item question bank shows that coded student needs can be translated into explicit game features. The material expert, media expert, and practitioner judged the product very feasible with scores of 87.50%, 97.50%, and 93.75%, and 26 responding students reached a mean agreement of 95.60%. These findings answer both research questions and indicate that the product is ready for wider classroom trials after minor refinements.

Teachers can use the product as a team-based practice activity after concept instruction, with the scoring rules and team roles explained before the first round.

Developers should refine the answer keys, item wording, replay options, and onboarding flagged by the assessors and students. Future researchers should test learning outcomes through controlled designs with larger samples, several classes, and additional topics. Studies on implementation fidelity and long-term retention would extend the evidence for TGT-based practice games.

AI Use Statement

The authors used Claude AI to assist with proofreading and language editing of the manuscript. ChatGPT was used to support the design and creation of visual elements for the web application. All AI-generated and AI-assisted outputs were reviewed and refined by the authors, who take full responsibility for the content of this manuscript.

Author Contributions

FBU: contributed to conceptualization, methodology, software development, data collection, data analysis, and manuscript drafting. EK: contributed to supervision, validation, and manuscript review. NM: contributed to conceptualization, methodological guidance, and manuscript revision. NA; AS: contributed to theoretical review, interpretation of findings, and manuscript editing. All authors reviewed and approved the final manuscript.

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Conflict of Interest

The authors declare no conflict of interest.

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