

Developing RENATAMA (Reyog Kendang & Etnomathematics) Based on Digital Board Game with Cognitive Psychology Content to Improve Numeracy Literacy

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Abstract

Mathematical literacy plays an important role in using mathematics to solve real problems. Based on the PISA results, Indonesia's mathematical literacy is currently ranked in the bottom 15, although in general it has increased compared to the previous year. This is in line with the results of the Minimum Competency Assessment in Tulungagung Regency which shows that numeracy literacy skills are still low. This research aims to: (1) to develop an android application as a learning media in the form of digital board game based on PBL with cognitive psychology content to improve Numeracy Literacy, and (2) to know the feasibility level of the android application as a learning media based on digital board game based on PBL with cognitive psychology content to improve Numeracy Literacy. The application is collaborated with the local cultural content of Reyog Kendang and is acronymised RENATAMA. This research uses the Research and Development (R&D) method using the ADDIE development model. The research subjects included 1 media expert, 1 material expert, and seventh grade students at SMPN 1 Sumbergempol and SMPN 3 Tulungagung. The data collected in the form of qualitative data in the form of interview results and quantitative data in the form of a percentage of feasibility test results. The questionnaire used in this study has aspects that are in accordance with the ISO / IEC 9126 model. The results of this study, show: (1) the RENATAMA (Reyog Kendang & Etnomathematics) based on Digital Board Game with Cognitive Psychology content to improve Numeracy Literacy, and (2) the developed application is declared feasible to use. Feasibility is obtained from the results of the feasibility test with details: (1) Media experts with a percentage of 91.5%; (2) Material experts with a percentage of 96%; (3) Small group test of 88.8%; and (4. Large group test with a percentage of 89%. From the results of this study, it can be categorized as 'Very Feasible'. So, the android application that has been developed is very feasible to use as a learning media. The advantages are through the use of technology compared to conventional ethnomathematics, originality, adoption of assets and integrated content of culture with mathematics, partnership with regular evaluation, involvement of lecturers and students to encourage the achievement of IKU-PT and being able to motivate themselves according to the goal of increasing numeracy literacy. The novelty is in combining cultural exploration of reyog kendang and PBL-based mathematics with a cognitive psychology approach to improve numeracy literacy, as well as pride in local culture through the RENATAMA.

1. Introduction

Mathematical literacy is a high-level ability that makes students have the capacity to apply its use in real-world contexts (Masfufah, et. al., 2021). Results from PISA (OECD) in 2022 stated that Indonesia's current ranking is in the bottom 15, although in general it rose 6 ranks (learning loss due to the impact of the COVID-19 pandemic) but the numeracy score was only 366 points and fell 13 points compared to 2018 (Pakpahan, et. al., 2021). Previous research on mathematical literacy has been conducted through the use of technology and shows the need for the development of media, teaching materials, strategies and models, with the contributing factors being: (1) not used to literacy-based questions; (2) types of questions tend to only use formulas; (3) focus on memorisation, not the development of reasoning skills (Saputri, et al., 2022) (Natsir, et. al., 2021).

Various efforts have been made to improve numeracy literacy, one of which is through the *Kampus Mengajar* (KM) programme through MBKM in Higher Education with the output of literacy habituation and numeracy strengthening using adaptive technology. Based on the post-test results of the Minimum Competency Assessment (AKM) of the KM Programme in Tulungagung Regency in 2023, at the level of primary and secondary education units, a low average (63%) was obtained. Furthermore, the Tulungagung Education Office programme through the School Literacy Movement with numeracy content has been massively carried out since

the last 6 years, but the results have not been significant. Numeracy literacy is also a measure of the success of the AKM which aims to map the quality of education and learning as a whole, but data from the Tulungagung District Education Office until the end of 2023 has not met the target (65%) in solving numeracy literacy questions adapted from PISA (Saputri, et, al., 2021)

The art of Reyog Kendang in Tulungagung Regency is a folk dance composition since 1978 that depicts the procession of soldiers of Kedhirilaya's troops when accompanying the bride of Ratu Kilisuci to Mount Kelud to witness the work of *Jathasura* regarding the requirements he gave. The art is known by the people of Tulungagung in the form of a simple entertainment dance performed by dancers while playing *kendhang dhodhog*. In its performance, Reog Kendang is performed in groups of six dancers, each of whom carries a *kendang* or *dhodhog*. In the Reyog Kendang performance, the dancers dance energetically while playing their drums in rhythm with the accompanying music and singing Javanese songs. The musical instruments used by the accompaniment are *kenong*, *gong* and *trumpet*. The *kenong* and *gong* used use a 5 *slendro* tone instrument. The following images below are the types of tools or properties used as shown in Figure 1 below.

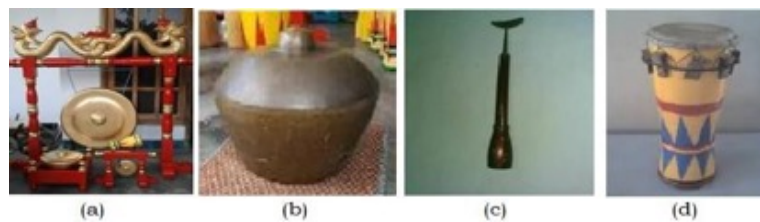


Figure 1. (a) gong; (b) kenong; (c) slompret; (d) kendhang dodok

With one unit, a line of 6 dancers can organise movements in the form of configurations or floor movements. The floor movement depends on the choreographer who has agreed together. But in addition to being free in floor movements, it is necessary to pay attention to the types of dance movements that are fixed or standardised by resting on head and foot movements. Among these dance movements are the following: (a) row motion; (b) *sundangan* motion; (c) *andul* motion; (d) *menthokan* motion; (e) *gejoh bumi* motion; (f) *ngongak sumur* motion; (g) *midak kecil* motion; (h) *lilingan* motion; and (i) *kejang* motion (5). In Figure 2 below is an example of the motion representation in Reyog Kendang above.



Figure 2. (a) sundangan; (b) lilingan; (c) gejoh bumi

These are the standard movements in Ryeog Kendang, while the length of each movement is counted as eight pieces. For the change of motion will be given a *dhodhog kerep* signal. So on, except for adjusting to the floor movement or forming a configuration, the length adjusts to the needs. The costumes used by the dancers are special costumes that depict soldiers in ancient times. Reyog Kendang is still often performed in various cultural festivals, both at the regional and national levels. Along with the times this dance began to see many changes, with the addition of various variations in terms of movement, costumes, musical accompaniment or presentation. This is done a lot to make it look more attractive, but not to leave the original form. In Figure 3 below are the costumes and accessories used by Reyog Kendang dancers.

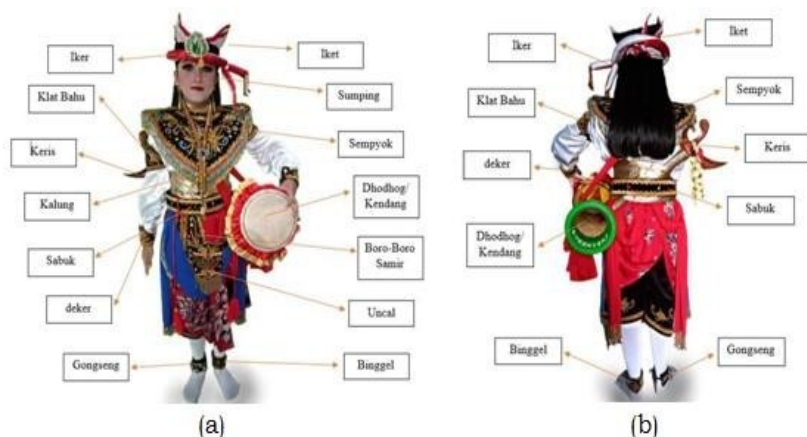


Figure 3. (a) front view; (b) back view

Reyog Kendang can also be related to Mathematics materials at the primary and secondary levels, namely regarding its concepts and activities (Yahya, 2019). For example, the mathematical concepts of number, geometry, and measurement based on the exploration results are:

- a. Numbers consist of: (a) natural numbers that appear when the dancers count the movements; (b) comparison of two numbers in the number of drum dancers; (c) multiplication counting operations in the repetition of dance movements; (d) number patterns in the drum music accompaniment as dance accompaniment.
- b. Geometry and Measurement consists of flat and spatial shapes based on exploration of costumes, props, musical instruments, and floor patterns. The flat shapes consist of; (a) a square in the shape of the *jarik* used by the drum dancer; (b) a rectangle seen in the *sampur*; (c) a parallelogram seen in the drum dancer's *jarik* motif; (d) a triangle found on the front of the *udeng* worn on the dancer's head and the wall decoration; (e) a circle seen in the floor pattern when the drum dancer performs the inward, outward, and *silat* movements; and (f) a trapezoid seen in the wooden machete carried by the dancer. While in the building space consists of: (a) tube can be seen from the shape of the drum used as musical accompaniment; (b) ball can be seen in the *gongseng* worn on the dancer's feet; (c) folding symmetry is found in the wall decoration.
- c. The type of angle that can be seen from dance movements with the position of hands and feet while dancing forming an angle. Then also the standard unit where the length of the distance travelled with the location and the non-standard unit appears when Reyog Kendang dancers set the distance.

In Reyog Kendang there are also mathematical activities (Nurhayati, 2022), among these mathematical activities are as follows: (a) counting, an activity in Reyog Kendang that appears when dancers perform counts on each dance movement. (b) measuring, when the drum dancers adjust the distance between dancers and the procession between dancers is carried out by stretching their arms and also stepping their feet; (c) locating, activities that arise when dancers determine the route of the procession and the determination of the route is carried out with the help of current mobile applications; (d) designing, activities that arise when dancers wear costumes and dance properties with the aim that dancers look attractive; (e) explaining, activities in Reyog Kendang can be implemented by mentioning the shape of dance properties and musical instruments that resemble flat and spatial shapes; and (f) playing, activities that can be seen from Reyog Kendang movements in accordance with the *pakem*, although it is possible for dancers to be free to make movements as long as they can still be adjusted to the accompaniment so as to train critical thinking in students.

From the explanation above, it is then represented through the RENATAMA application (Reyog Kendang & Ethnomathematics) with Learning Object Material (LOM) content that brings up videos, animations, infographics and game-shaped descriptions that allow identifying problems, planning solutions, and providing answers and feedback (Küçük, A., 2014). In addition, PBL is based on cognitive psychology according to the level of understanding of Reyog Kendang culture. Then formative evaluation becomes an integral part of the process, periodic feedback and reflects the improvement of numeracy literacy. In contrast to previous developments that only implement in general through textual context, enrichment questions or literature (Saefurohman, et, all., 2021), there are adjustments to individual needs (cognitive psychology), diverse learning environments and culture. The novelty lies in combining cultural exploration (Reyog Kendang) with PBL-based mathematics with a cognitive psychology approach through a board game on an android platform to improve numeracy literacy, as well as pride in local culture. Thus, the proposed approaches and methods not only provide adaptive solutions to the objectives, but also incorporate innovative elements to improve numeracy literacy skills (Sulayakin & Kurniawan, 2019

The development of the RENATAMA application is not only an innovation in improving numeracy literacy involving lecturers and partners, but also a reflection of a shared commitment to creating a generation that has an understanding of mathematics while preserving regional culture with the use of relevant technology in facing future challenges (Dantes & Handayani, 2021). Researchers are interested in contributing to the above phenomenon supported by expertise in the field of educational psychology through research on the interpretation of culturally appropriate mathematics in Tulungagung Regency. Previous research related to ethnomathematics, the results were effective in increasing students' understanding. In addition, getting to know the arts is a form of cultural responsibility to preserve it amid the current globalisation in the current disruption era.

2. Method

In the development of the RENATAMA application through a PBL-based digital board game with cognitive psychology content to improve numeracy literacy in the research procedure adapts the ADDIE development model which consists of 5 stages (Miles, M. B., Huberman, et, all., 2014), which includes the stages of analysis, design, development, implementation, and evaluation. Then the ADDIE development steps in this study if presented as in Figure 4.

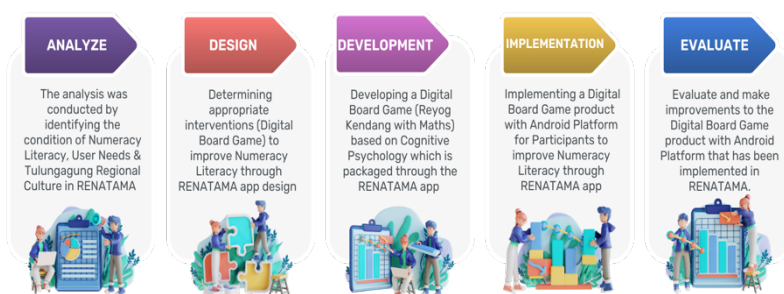


Figure 4. RENATAMA Development Steps

Furthermore, the data source in this study is data obtained from respondents of seventh grade students at SMPN 1 Sumbergempol and SMPN 3 Tulungagung, East Java and carried out between June and October 2024. The withdrawal of research samples using multistage cluster sampling techniques, then the data collection techniques and instruments of this study are used as a basis for determining the level of effectiveness, efficiency, or attractiveness of the products produced. The type of data in this research is qualitative data taken through interviews, observations, documentation studies, critical appraisal checklist questionnaires, field needs questionnaires and delphi questionnaires. In the critical appraisal and delphi analysis for the second type of data in this study using quantitative data, collected through the results of the numeracy literacy test adopted from PISA (Cole, M. L., & Stavros, J. M., 2013), then analysed descriptive statistics. Data collection techniques and procedures in this study were using questionnaires. This technique is done by collecting information from questionnaire data that has been given to several expert experts and student respondents in the form of input, responses, criticisms, and suggestions. After obtaining the results in the form of data, the next stage is to analyse the data (Smaldino, et, all., 2008). The data analysis process will be carried out using a combination of qualitative and quantitative data analysis.

3. Results and Discussion

3.1. Results

Based on the ADDIE development model procedure as described above, the details of the analysis and design stages and the development of the RENATAMA application are: **First**, at the analysis stage, researchers used observation and interview methods at SMPN 1 Sumbergempol and SMPN 3 Tulungagung and obtained data: (a) based on the syllabus and curriculum analysis of the mathematics subjects taught; (b) forms of digital transformation in education; (c) learning is carried out with a combination of asynchronous and the use of technological devices, but not yet massive; (d) the number of Mathematics Subject package books is still limited; (e) face-to-face learning activities through lectures; (f) the habits of students outside of learning are mostly playing games, listening to music, and watching YouTube. Based on the results of observations and interviews conducted by researchers, it is necessary to detail the appropriate product in the form of an application that can run on a smartphone with an android operating system and contains learning objectives that can motivate students. In addition, it contains several features that can make students learn to manage themselves. Then the material presented comes from packaged books and internet summaries so that students get learning experience and of course it must be in accordance with the Teaching Modules in the School.

Second, the design stage is the stage of designing an android application system that can be used as a learning medium and can be seen in Figure 5 about the application flowchart in the form of a diagram that displays the steps and decisions to carry out the application development process.

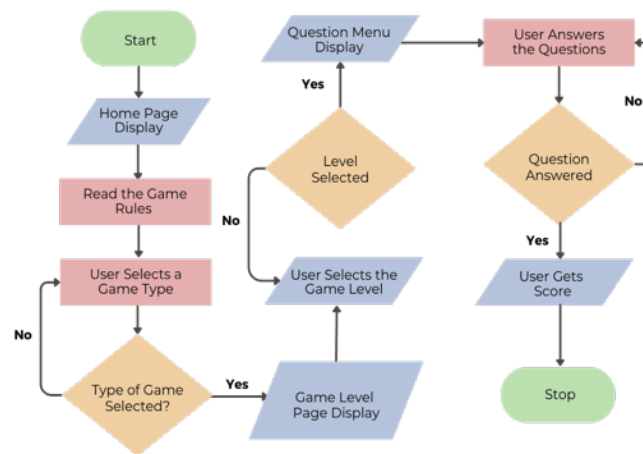


Figure 5. RENATAMA Application Flowchart

From the application flowchart above, it is then developed in the form of a storyboard as a prototype in the development of the RENATAMA application as Figure 6 as follows below.

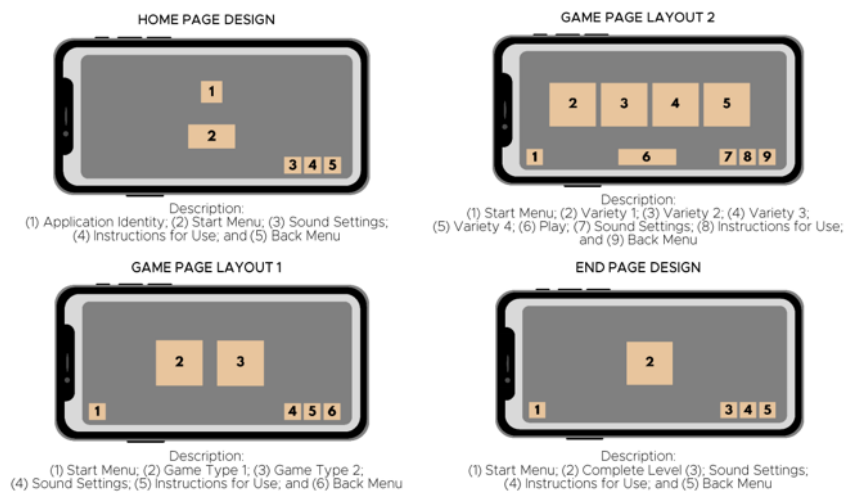


Figure 6. Storyboard of RENATAMA Application

Furthermore, the storyboard as a prototype in the development of the RENATAMA application has 5 main menus in the form of: (a) KI, KD and Objectives that provide information in accordance with the curriculum at the secondary education level; (b) material menu about mathematics, cognitive psychology, PBL and Reyog Kendang; (c) evaluation menu used to measure student learning outcomes; (d) application usage menu; and (e) a menu that contains application developer information..

Third, at the stage of developing the RENATAMA application based on Digital Board Game with Cognitive Psychology content to improve Numeracy Literacy in this study using Construct 2. The display results of the development stage are as follows in Figure 7 below:



Figure 7. RENATAMA Application View

On the display of the RENATAMA Application there is an initial display of the title that describes the content of the material, a start button that will direct to the main menu of the application. Furthermore, the main menu display is developed with a game type menu, information about core competencies and basic competencies with levels or levels that must be done, instructions for use, developer information and exit buttons. In addition, there is a display of achievement levels with an evaluation menu selected by students and a quiz display that students can do.

Furthermore, the media expert feasibility test in the development of the RENATAMA application based on Digital Board Game with Cognitive Psychology content to improve Numeracy Literacy was carried out by media experts, with the results of the media expert feasibility test can be seen in Table 1.

Table 1. Result of Media Expert Feasibility Test

No	Aspect	Description	Score	Description
1	Functionality	Performs required functions	5	Very Feasible
		Conforms to expectations	4	Feasible
		Compliant with android system	5	Very Feasible
		Security	5	Very Feasible
2	Reliability	Hardware compliant	4	Feasible
		Performance against hardware and software errors	5	Very Feasible
		Recovery if something goes wrong	5	Very Feasible
3	Usability	Ease of use of the app	5	Very Feasible
		Ease of learning the app	5	Very Feasible
		Ease of use on android	5	Very Feasible
		Interface quality	5	Very Feasible
4	Efficiency	Response speed between menus	5	Very Feasible
		Resource utilisation efficiency	5	Very Feasible
5	Maintainability	Ease of identifying errors	4	Feasible
		Ease of fixing the error	4	Feasible
		Stability once fixed	4	Feasible
		Changes can be recognised easily	4	Feasible
6	Portability	Successful installation on smartphones	4	Feasible
		Ease of installing the app	4	Feasible
Score Total			87	

From the table above, the score obtained through the media expert feasibility test is 87 or with a total percentage of 91.5% of the maximum score of 95. Based on the calculation of the percentage of feasibility of the media expert feasibility test, the RENATAMA application based on Digital Board Game with Cognitive Psychology content to improve Numeracy Literacy is included in the 'Very Feasible' category to be applied.

The material expert feasibility test was carried out by a mathematics teacher with the results of the material expert feasibility test can be seen in Table 2.

Table 2. Results of Material Expert Feasibility Test

No	Aspect	Description	Score	Description
1	Functionality	Performs required functions	5	Very Feasible
		Conforms to expectations	5	Very Feasible
		Compliant with android system	4	Feasible
		Security	5	Very Feasible
2	Reliability	Hardware compliant	4	Feasible
		Performance against hardware and software errors	5	Very Feasible
		Recovery if something goes wrong	5	Very Feasible
3	Usability	Ease of use of the app	5	Very Feasible
		Ease of learning the app	5	Very Feasible
		Ease of use on android	5	Very Feasible
		Interface quality	5	Very Feasible
4	Efficiency	Response speed between menus	5	Very Feasible
		Resource utilisation efficiency	4	Feasible
5	Portability	Successful installation on smartphones	5	Very Feasible
		Ease of installing the app	5	Very Feasible
Score Total			72	

From the table above, the score obtained from the material expert feasibility test is 72 or with a total percentage of 96% of the maximum score of 75. Based on the calculation of the percentage of feasibility of the material expert feasibility test on the learning media feasibility scale, the RENATAMA application based on Digital Board Game with Cognitive Psychology content to improve Numeracy Literacy is included in the 'Very Feasible' category to be applied.

Fourth, at the implementation stage, a small group test was conducted in the form of a questionnaire to 5 random students at SMPN 1 Sumbergempol and SMPN 3 Tulungagung. The results of the small group trial can be seen in Table 3 below:

Table 3. Results of Small Group Trial

No	Aspect	Description	Score	Percentage	Description
1	Functionality	Performs required functions	22	88%	Very Feasible
		Conforms to expectations	22	88%	Very Feasible
		Compliant with android system	21	84%	Very Feasible
		Security	24	96%	Very Feasible
2	Reliability	Hardware compliant	22	88%	Very Feasible
		Performance against hardware & software errors	23	92%	Very Feasible
		Recovery if something goes wrong	24	96%	Very Feasible
3	Usability	Ease of use of the app	23	92%	Very Feasible
		Ease of learning the app	22	88%	Very Feasible
		Ease of use on android	22	88%	Very Feasible
		Interface quality	20	80%	Very Feasible
4	Efficiency	Response speed between menus	22	88%	Very Feasible
		Resource utilisation efficiency	20	80%	Very Feasible
5	Portability	Successful installation on smartphones	22	88%	Very Feasible
		Ease of installing the app	24	96%	Very Feasible
Score Total			333		

From the table above, the score obtained through the small group trial is 333 or with a total percentage of 88.8% of the maximum score of 375. Based on Table 3 on the learning media feasibility scale, the RENATAMA application based on Digital Board Game with Cognitive Psychology content to improve Numeracy Literacy is included in the 'Very Feasible' category to be applied in learning activities.

In the large group trial stage, a sample of 30 students was taken. The samples were VII grade students at SMPN 1 Sumbergempol (15 students) and SMPN 3 Tulungagung (15 students). The results can be seen in Table 4 below:

Table 4. Results of Large Group Trial

No	Aspect	Description	Score	Percentage	Description
1	Functionality	Performs required functions	132	88%	Very Feasible
		Conforms to expectations	131	87.3%	Very Feasible
		Compliant with android system	134	89.3%	Very Feasible
		Security	140	93.3%	Very Feasible
2	Reliability	Hardware compliant	131	87.3%	Very Feasible

No	Aspect	Description	Score	Percentage	Description
3	Usability	Performance against hardware & software errors	131	87.3%	Very Feasible
		Recovery if something goes wrong	130	86.7%	Very Feasible
		Ease of use of the app	136	90.7%	Very Feasible
		Ease of learning the app	137	91.3%	Very Feasible
		Ease of use on android	138	92%	Very Feasible
4	Efficiency	Interface quality	129	86%	Very Feasible
		Response speed between menus	131	87.3%	Very Feasible
5	Portability	Resource utilisation efficiency	129	86%	Very Feasible
		Successful installation on smartphones	132	88%	Very Feasible
		Ease of installing the app	131	87.3%	Very Feasible
Score Total			2002		

From the table above, the score obtained through the large group trial is 2002 or with a total percentage of 89% of the maximum score of 2250. Based on the calculation of the percentage of feasibility of the large group trial, the RENATAMA application based on Digital Board Game with Cognitive Psychology content to improve Numeracy Literacy is included in the 'Very Feasible' category to be applied in learning activities.

Fifth, at the product evaluation stage which is an analysis of the product that has been developed based on the data obtained from product trial activities and there may be input for product improvement. From the results of the analysis, product revision will then be carried out. Product revision is a stage of product improvement so that the final result of product development is better. The following is the final data from the trial stage which includes media expert feasibility tests, material expert feasibility tests, small group trials and large group trials. The data can be seen in the Table 5 below:

Table 5. Maximum Score

Aspect	Score	Maximum Score	Percentage	Description
Media expert feasibility test	87	95	91.5 %	Very Feasible
Material expert feasibility test	72	75	96 %	Very Feasible
Small group trial	333	375	88.8%	Very Feasible
Large group trial	2002	2250	89%	Very Feasible
Average			91.3%	Very Feasible

3.2. Discussion

Furthermore, the success indicators in the activity programme from the results of the development of the RENATAMA application through this digital board game have a feasibility score of > 85% and are able to improve the numeracy literacy skills of students, especially at the junior high school level. As for the follow-up plan for this programme, among others are: (1) the realisation of the dissemination of the results of the RENATAMA application through a PBL based digital board game with cognitive psychology content to improve the numeracy literacy of grade VII students at the junior high school level in Tulungagung Regency; (2) upload, submit and release the application on the Google Play Store through the Google Play Developer Console so that it can be accessed by all users; (3) make periodic improvements to the RENATAMA application; and (4) become one of the indicators of decision-making considerations by education stakeholders, especially the Tulungagung Regency Education Office related to policies in efforts to improve the literacy and numeracy of students in primary and secondary education units.

As for the advantages of the RENATAMA application through this digital board game are: (1) the use of technology because so far the ethnomatics approach model is still conventional; (2) originality and adoption of assets from license-free content that integrates culture with mathematics; (3) partnership with the Tulungagung Education Office through KKG and MGMP mathematics periodically; (4) involvement of lecturers and students to encourage the achievement of IKU-PT; (5) application design with easy-to-understand features released on the google play store, so that it can be accessed anytime and anywhere; and (6) self-motivation according to the goal of increasing numeracy literacy; and (7) self-management, learning experiences and self-assessment as a reference for mastering the level of material.

4. Conclusion

Mathematical literacy plays an important role in using mathematics to solve real problems. Based on the PISA results, Indonesia's mathematical literacy is currently ranked in the bottom 15, although in general it has increased compared to the previous year. This is in line with the results of the Minimum Competency Assessment (AKM) in Tulungagung Regency which shows that numeracy literacy skills are still low. The results of this study, show that the RENATAMA application based on Digital Board Game with Cognitive Psychology content to improve Numeracy Literacy and feasible to use as one of the media in learning. Its advantages through the use of technology compared to conventional ethnomathematics, are originality, adoption of assets and

content integrated culture with mathematics, able to motivate themselves according to the goal of increasing numeracy literacy. The novelty is in combining PBL-based cultural and mathematical exploration with a cognitive psychology approach, as well as pride in local culture through the RENATAMA application. Researchers are consistent with their expertise (scientific clusters) in developing their own capacity. The development of the RENATAMA application is not only an innovation in improving numeracy literacy that partners with the Tulungagung Regency Education Office and MGMP Mathematics at the Primary and Secondary Education Unit levels, but also a reflection of a shared commitment to create a generation that has an understanding of mathematics while preserving local culture with the use of relevant technology in facing future challenges. As part of our commitment as lecturers to improve the quality of education in the digital era, the completion of this programme is also an important milestone in the development of innovative learning methods based on information technology.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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