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Digital Education Game for TK-A Level Students Using Multimedia Development Life Cycle Method

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Abstract—COVID-19 pandemic has changed human life. One of the impacted sectors is education. Ministry of Education urges students to implement distance learning. No exception with early childhood education or Pendidikan Anak Usia Dini (PAUD). Although distance learning has been widely implemented, PAUD sector has the lowest online learning implementation in Indonesia with 13.2% of total 98.4% of PAUD students implementing distance learning, whereas early age is considered capable of gaining an understanding of digital technology and equipment. One possible step in conducting digital learning in PAUD is through a digital educational game, because game is an important element in PAUD. In this study, a digital educational game was developed for TK-A level students using Scratch 3 with multimedia development life cycle method. After development, the game goes through two stages of testing. Alpha testing in the form of black box testing, and beta testing in the form of usability testing with 94,39% result, confidence testing with 97,8% result, and summative evaluation with 90% result on TK-A students, as well as interviews with PAUD teachers. The test results indicate that the game has been successfully developed and is feasible to be played by TK-A students.

Keywords— Educational Games; Multimedia Development Life Cycle; Usability Testing

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I. INTRODUCTION

The COVID-19 pandemic has changed many aspects of human life. The education sector is no exception. Through Circular Letter Number 4 of 2020 [1] concerning the Implementation of Educational Policies in the Emergency Period for the Spread of Coronavirus Disease (COVID-19) issued by the Minister of Education and Culture (Mendikbud) explained several things related to controlling the spread of COVID-19 in the educational environment. One of them states that students must do online/distanced learning. This encourages educational institutions to switch from conventional learning systems to online learning systems.

Early Childhood Education or Pendidikan Anak Usia Dini in Indonesian (PAUD), according to the Law of the Republic of Indonesia Number 20 of 2003 concerning the National Education System article 1 paragraph 14, is a coaching effort aimed at children from birth to the age of 6 years which is carried out through the provision of educational stimuli to help physical and spiritual growth and development so that children have readiness to enter further education. PAUD in formal education can be in the form of kindergarten (TK), raudatul athfal (RA) / bustanul athfal (BA), or other forms. Kindergarten provides education for students aged 4 to 6 years to develop personality and self-potential according to the stages of development of the students, while RA/BA is the same education system as kindergarten but is under the auspices of the Ministry of Religion [2].

E-learning is a formal learning system using the help of electronic devices [3],[4]. The presence of e-learning provides a new perspective for the education system. E-learning allows things that previously could not be done by conventional learning methods can be done. Learning becomes more flexible because it can be done from anywhere and anytime.

However, early childhood is often considered unable to use technology to carry out learning activities. Data shown by the Ministry of Education and Culture through Antara [5], although 98.4% of PAUD students are learning from home during the COVID-19 pandemic, only 13.2% of students are doing online learning, the rest is still done using the assignment method through parents. to home visits. In fact, the application of technology in PAUD education has been widely applied throughout the world. For example, The 2016 Finnish National Core Curriculum for Early Childhood Education requires that children's information and communication technology competencies need to be supported from early childhood education [6]. Research conducted by Liu [7],[8] also shows that the application of technology in early childhood education in China and Greece has a positive contribution to children's knowledge and development. This strengthens the argument that early childhood is actually capable of gaining an understanding of technology and digital equipment [9],[10]. In addition, utilizing online learning can increase the closeness

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between parents and children, because parents can be directly involved in children's learning development [11], [12], [13],[14].

The implementation of e-learning system in PAUD level education is certainly a new challenge. Games are very important aspect for early childhood development [15]. So, the development of game-based e-learning systems is more suitable to be applied to early childhood. However, the PAUD curriculum that has been prepared previously is designed to be carried out using conventional learning methods, so adjustments are needed to form a digital game that is in accordance with the existing PAUD curriculum.

Similar previous research creating educational games for students especially for kindergarten students have been done before. Research conducted by Rahman [16],[17] created an education game recognition of animal names and their habitats in 3 languages using MDLC method. This study aims to increase students' interest in learning, help the development of intelligence and improve children's abilities in the learning process at an early age. The concept stage includes user and application concepts. The design phase includes the navigation structure and storyboard. At the material collecting stage, the game supporting materials such as images and audio are collected. The assembly stage includes the creation of games based on the collected materials and the design carried out at the design stage. At the testing stage of this research, alpha testing and beta testing were carried out. Alpha testing includes black box testing, while beta testing includes questionnaires for PAUD and SD students. Furthermore, research conducted by Nuqisari [18], [19] made an android solar system educational game. The method used in this study is the System Development Life Cycle with waterfall model. The game is created using Construct 2 application. At the testing stage, black box and usability testing were carried out with the System Usability Scale questionnaire. The results of the black box test run without problems, and the usability test gets a value of 66.25. The key word from this research is that the games made can be used properly and are considered good enough to help the student's learning process.

Based on the description above, this research was conducted to develop a digital educational game for TK-A students. After the game has been developed, several tests will be carried out. Among them are usability testing, confidence testing, and summative evaluations conducted on students, as well as game competency suitability tests for teachers. Usability testing is done to find out whether users can easily use the game. Confidence testing is done to find user confidence level while using the game. Summative evaluation is carried out to determine students' learning abilities or how much learning material in the game has been achieved in accordance with curriculum achievements. The competency suitability test is used to determine whether the game is feasible to use and has successfully adopted the existing curriculum.

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II. RESEARCH METHOD

In this research, the method used to develop the game is multimedia development life cycle. According to Luther in Binanto [20], there are 6 stages in the MDLC process, namely, concept, design, material collecting, assembly, testing, and distribution.

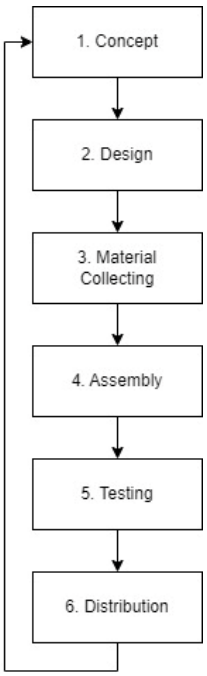

Figure 1. MULTIMEDIA DEVELOPMENT LIFE CYCLE[20]

In concept stage, problems of the game will be identified. This includes objectives, user targets, and the concept of the multimedia that will be developed. Next, during the design stage, the overall design of the multimedia will be created in form of storyboard and navigation structure. The material needed for the design of the multimedia will be collected, either taken from the internet or created manually. During the assembly stage, the multimedia will be created by using the materials collected from the previous stage.

Then, testing will be conducted in two phases, alpha testing, and beta testing. Alpha testing will use only black box testing, and beta testing involves usability testing, confidence testing and summative evaluation. Beta testing involves users and experts directly, which are 5 kindergarten TK-A level students, and 2 kindergarten TK-A level teachers. The usability aspects used are based on ISO 9421-11 [21] that includes effectiveness, efficiency, and satisfaction. Efficiency and efficiency will be tested using performance testing, where user will do the test scenarios created by the developer. Satisfaction aspect of usability, confidence testing, and summative evaluation are done using questionnaire. Interview with the teachers will be conducted to find comments and suggestion related to the game.

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The effectiveness aspect will be tested to find the level of user success in using the developed game. A score of 1 will be awarded for tasks that can be completed without the assistance of the examiner, a score of 0.5 for tasks completed with the assistance of the examiner, and a score of 0 for tasks that are not completed successfully. The results obtained are then reprocessed using the success rate formula adapted from [22],[23] to get the final value from the effectiveness aspect as follows:

$$Success\ Rate = (Success+(Partial\ Success \times 0,5)) / (Total\ Task) \times 100\% \quad (1)$$

The efficiency aspect is based on the time it takes the user to use the developed system. Time will be measured in seconds, and will be calculated using the following formula adapted from [24]:

$$Successful\ Tasks = (Total\ Successful\ Tasks\ Time) / (Total\ Time) \times 100\% \quad (2)$$

The satisfaction aspect of usability and confidence testing will be conducted using questionnaire adapted from Nugraheni & de Vries [25]. The satisfaction aspect and confidence testing and will be calculated using the following formula adapted from [26]:

$$Final\ Score = (Actual\ Score) / (Ideal\ Score) \times 100\% \quad (3)$$

Measuring aspects of effectiveness, efficiency, and satisfaction will be interpreted using an assessment standard adapted from research conducted by Nugraheni [27]. The standard of assessment on the aspects of effectiveness, efficiency, and satisfaction is described in Table 1 below.

Table 1. USABILITY TESTING ASSESSMENT STANDARDS[27]

Percentage (%)	Level of Effectiveness	Level of Efficiency	Level of Satisfaction
0% - 20%	Ineffective	Inefficient	Unsatisfied
21% - 40%	Less Effective	Less Efficient	Less Satisfied
41% - 60%	Moderate	Moderate	Moderate
61% - 80%	Effective	Efficient	Satisfied
81% - 100%	Very Effective	Very Efficient	Very Satisfied

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The standard of assessment on the aspects of confidence is described in Table 2 below.

Table 2. CONFIDENCE TESTING ASSESMENT STANDARDS

Percentage (%)	Description
0% - 20%	Lack of Confidence
21% - 40%	Uncertain
41% - 60%	Moderate
61% - 80%	In Confidence
81% - 100%	More Confidence

Summative evaluation is in the form of a questionnaire with 4 questions where each question on the questionnaire with each question is compiled from each minigame. Questions are arranged in a multiple-choice format with 1 correct choice among 1 or more incorrect choices. The results of this questionnaire are used to determine students' ability to understand and recall the questions in the game. The results of the summative evaluation are then interpreted using an assessment standard adapted from research conducted by Taufiqurrahman [28]. Assessment standards for summative evaluation can be seen in Table 3 below.

Table 3. SUMMATIVE EVALUATION ASSESSMENT STANDARDS [28]

Percentage (%)	Description
0% - 20%	Very Low
21% - 40%	Low
41% - 60%	Moderate
61% - 80%	High
81% - 100%	Very High

After all the testing finished, then the multimedia will be distributed. In this research, the process finishes at distribution stage.

III. RESULT AND DISCUSSION

A. Concept

In the concept phase, we first need to adapt the game with the existing TK-A level PAUD curriculum, so that the developed games do not eliminate the essence of learning from the existing curriculum. By referring to the guidelines for preparing the Education Unit Level Curriculum (KTSP) for Early Childhood Education issued by the Ministry of Education and Culture of the Republic of Indonesia [29], several competencies will be taken from the curriculum in the

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document, especially in the physical motoric, cognitive, and language aspects. The selected competencies will then be implemented in the game.

The game will be developed into 4 minigames. Each minigame will be developed by adopting several combinations of pre-selected competencies. The four minigames that will be developed consist of the following:

1. Minigame to group shapes,
2. Minigame to count the number of objects,
3. Minigame to compare the number of objects, and
4. Minigame to match uppercase letters with lowercase letters.

The list of competencies used in each minigames is shown in Table 4.

Table 4. LIST OF COMPETENCIES USED IN EACH MINIGAMES (SOURCE: AUTHOR)

Minigame	**Development Program**	**Competencies to be Achieved**[29]	**Learning Materials**[29]
Grouping Shapes	Physical Motoric	Using limbs for gross and fine motor development	Movements to develop gross motor skills (strength, balance, flexibility, agility, eye-hand-foot coordination, speed, accuracy)
	Cognitive	Have a behavior that reflects an attitude of curiosity	The habit of introducing new objects.
		Get to know the surrounding objects (name, color, shape, size, pattern, nature, sound, texture, function, and other characteristics)	Things in surroundings
Counting Objects	Physical Motoric	Using limbs for gross and fine motor development	Movements to develop fine motor skills (strength, flexibility, hand-eye coordination)
	Cognitive	Have a behavior that reflects an attitude of curiosity	The habit of introducing new objects.
		Get to know the surrounding objects (name, color, shape, size, pattern, nature, sound, texture, function, and other characteristics)	Things in surroundings
			Awareness of numbers (one-to-one relationships, sums, comparisons)
Comparing Number of Objects	Physical Motoric	Using limbs for gross and fine motor development	Movements to develop fine motor skills (strength, flexibility, hand-eye coordination)

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	Cognitive	Have a behavior that reflects an attitude of curiosity	The habit of introducing new objects.
		Get to know the surrounding objects (name, color, shape, size, pattern, nature, sound, texture, function, and other characteristics)	Things in surroundings
			Awareness of numbers (one-to-one relationships, sums, comparisons)
		Convey about what and how familiar objects around him (name, color, shape, size, pattern, nature, sound, texture, function and other characteristics) through various works	Measurements (large-small, many-little, long-short, lightweight, high-low, non-standard size, time, volume, temperature)
Matching Uppercase with Lowercase Letters	Physical Motoric	Using limbs for gross and fine motor development	Movements to develop fine motor skills (strength, flexibility, hand-eye coordination)
	Language	Recognizing early literacy through play	Reading symbols of letters and numbers

B. Design

The navigation structure was developed to connect each scene in the system to provide a clear picture of the flow of activities.

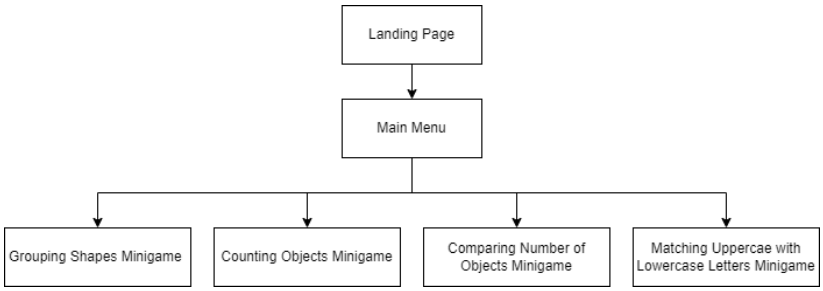

Figure 2. NAVIGATION STRUCTURE (SOURCE: AUTHOR)

When entering the game, the user will be shown the main page. From the main page, users can access the game's main menu. In the game's main menu, users can access every existing minigame. After creating navigation structure, the storyboard is made. Storyboard is an initial visualization of the system before development. The storyboard includes the interface design of the existing scenes on the system. The software used in making this storyboard is Adobe Illustrator. Some of the interface design of each minigame is shown on Figure 3.

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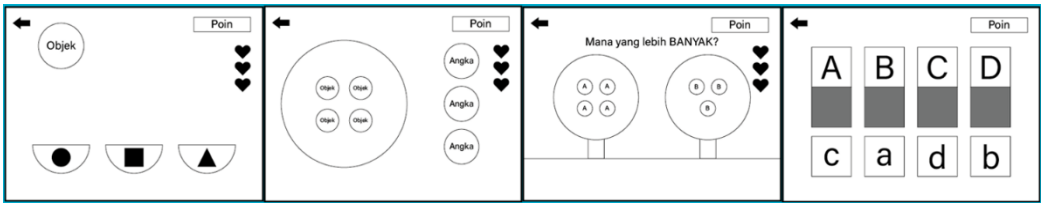

Figure 3. MINIGAME INTERFACES (SOURCE: AUTHOR)

C. Material Collecting

After creating navigation structure and storyboard design, the next step is to collect materials needed for the game. These assets include image illustrations, background illustrations, background audio, and voice-overs. The first asset to be collected is image illustrations. Image illustrations are a vital asset in creating visualizations that exist in the game. Images were taken from free copyright sites on the internet and/or made manually using Adobe Illustrator.

Figure 4. IMAGE ILLUSTRATIONS (SOURCE: AUTHOR)

The next illustration asset is the background. The purpose of making the background is to provide a happy and playful ambiance in the game. Each minigames has its own background, which is based on the locations the Miko character went into.

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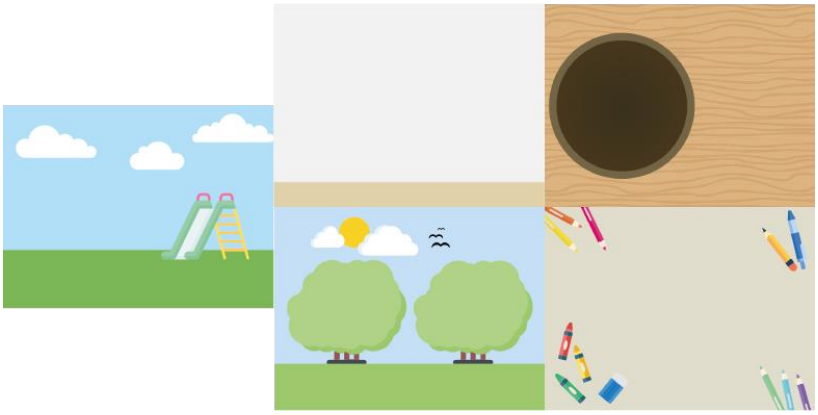

Figure 5. BACKGROUND ILLUSTRATIONS (SOURCE: AUTHOR)

The last assets to be collected are audio files. The audio assets are divided into two, background audio and voice-over audio. Background audio aims to make the game atmosphere more enjoyable for users, while voice-over audio aims to assist users in understanding the instructions on the system. Background audio is in the form of songs or sound effects, while voice-over audio is in the form of messages in Bahasa Indonesia.

Background audio is collected from free copyright audio from youtube.com and then converted into mp3 files via a web-based converter application. Then the audio is reprocessed using the Audacity. The voice-over audio is taken by the developer's own voice using the Audacity using the earphone microphones. After being collected, the audio voice-over is then reprocessed to get a sound effect that matches the game's theme.

D. Assembly

After all assets have been collected, they are then assembled and programmed using Scratch. Scratch is a program developed by the Massachusetts Institute of Technology (MIT) to program games and/or animations easily [30],[31]. The preview of the game is shown in Figure 6.

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Figure 6. PREVIEW OF THE FINISHED GAME (SOURCE: AUTHOR)

E. Testing

After the assembly is finished, the game is tested. Testing is divided into two phases, alpha testing which only involves the developer, and beta testing that involves end-user. The alpha testing uses black box testing method, in which all test cases are tested manually to see any defects that may affect the game. All blackbox testing scenarios tested positive according to the designed criteria.

The next phase is to do beta testing, that includes usability testing, confidence testing and summative evaluation on students, and interview on teacher. The testing was conducted on 6 TK-A kindergarten students and 2 kindergarten teachers. The number of respondents are based on Nielsen [32], which suggest a number from 5 to 8 respondents for the optimal results of usability testing. The test was conducted on student and teacher respondents at PAUD in Tembalang, Semarang , and additional testing was carried out on PAUD student respondents on. Gayamsari, Semarang on July 15, 2022.

The source of the data is separated into 3, performance measurement, questionnaire, and interview data. Performance measurement will retrieve the data for usability aspects of effectiveness and efficiency. The amount of performance measurement data will be based on the test scenario and number of respondents, which in this case is 5 students and 2 teachers. Questionnaires will retrieve data for the usability aspect of satisfaction, confidence testing, and summative evaluation. The amount of interviews data will be based on the questionnaires and number of respondents, satisfaction will have 3 questions, confidence testing will have 3 questions, and summative evaluation will have 4 questions. Interviews are conducted to retrieve information on the conformity of the game with the recurring curriculum from PAUD teachers as experts. To conduct performance measurement, a test scenario will be used. On effectiveness aspect, a test will be conducted on how user is able to do the test scenarios on the game easily. On efficiency aspect, the time used while performing each scenario will indicate how efficient the game on user. The test scenario of the game is shown on Table 5.

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Table 5. TEST SCENARIO (SOURCE: AUTHOR)

Class	Task	Description
Main Menu	Entering the main menu	User enters the main menu by pressing the "Start" button
Minigames	Choosing the places	User selects each minigames by directing Miko character to the places icons
	Entering the minigame	User enters the minigame by pressing the “Start” button
	Finishing the first round	User finishes the first round of the minigame by following the instructions
	Finishing the second round	User finishes the second round of the minigame by following the instructions
	Finishing the third round	User finishes the third round of the minigame by following the instructions
	Finishing the fourth round	User finishes the fourth round of the minigame by following the instructions
	Finishing the fifth round	User finishes the fifth round of the minigame by following the instructions
	Finishing the sixth round	User finishes the sixth round of the minigame by following the instructions
	Return to main menu	User returns to main menu by pressing the arrow button on the top left corner of the minigame when the game is finished or unfinished

The beta testing results are shown in Table 6.

Table 6. USABILITY AND SUMMATIVE EVALUATION RESULTS (SOURCE: AUTHOR)

Testing	Result	Description
Effectiveness	96,62%	Very Efficient
Efficiency	92,1%	Very Efficient
Satisfaction	94,44%	Very Satisfied
Confidence	97,8%	Very High confidence -
Summative Evaluation	90%	Very High

The next test carried out was interviews with kindergarten teacher respondents as experts on PAUD level education, especially at the TK-A level. Interviews were conducted to obtain information related to the game being developed. Interviews were conducted simultaneously with direct testing of games by teachers. The questions asked included responses, criticisms, and the suitability of the curriculum for the game being developed.

When the teachers were asked about the suitability of the TK-A curriculum adopted at PAUD with the game being developed, the respondents stated that the grouping shapes, counting objects,

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and comparing number of objects minigame was in accordance with the TK-A PAUD curriculum at PAUD. However, there are criticisms of the matching uppercase letters with lowercase letters minigame. Most of the TK-A level students at PAUD have not been taught capital letters, making it difficult for students who are not familiar with capital letters. This shows that there is a difference in the curriculum from the references circulated by the Ministry of Education and Culture with PAUD. This statement is also supported by the results of the summative evaluation of the minigame being lower than other minigames.

In terms of playing experience, the minigame grouping shapes is considered good by the teacher. Minigame counting the number of objects and comparing the number of objects is also considered good by the respondents. There are criticisms of the matching uppercase letters with lowercase letters minigame. The use of drag and drop in the minigame is also considered difficult for students. Many of the students had never used a computer and trackpad or mouse, so it was difficult for them to play the minigame. This problem is also strongly supported by the results of testing on the effectiveness aspect which has a lower success rate in the minigame compared to other minigames. The efficiency aspect also shows that students spend more time in this minigame than other minigames. To respond to this problem, respondents also gave suggestions for games to be developed for mobile devices with touchscreen input because PAUD students at TK-A level are more familiar with using touchscreen input.

There are suggestions regarding the number of players in the game. Games are expected to be developed for multiple players (multiplayer), so that students can interact with other fellow students.

F. Distribution

After testing, the game then enters the distribution stage. The final result of this research is a master file of the game with a game usage manual. The master file of the game is in HTML format so that it can be operated in a browser. The manual was developed using Adobe Illustrator. The final master file and manual are then distributed to PAUD in Semarang .

IV. CONCLUSION

Based on the results, the digital education game for TK-A level students has been developed successfully and acceptable to be played by the TK-A level kindergarten students. This result is supported by the beta testing results. The result for the effectiveness aspect is 96,62% which translates to very effective, efficiency aspect is 92,1% which translates to very efficient, satisfaction aspect is 94,44% which translates to very satisfied. The result of the confidence testing is 97,8% and summative evaluation is 90% which directly translates to a very high score.

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After conducting interview with the teachers, the game can be used as an alternative learning method for students. This is supported by the statement that the game is appropriate and has successfully adopted the existing curriculum. However, some suggestions were obtained, including making games that are intended for mobile devices with touchscreen input. This is because many PAUD students at TK-A level have and are familiar with mobile devices with touchscreen input. In addition, the game can also be developed not only for 1 player (single player) but can also be developed for several players (multiplayer)

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