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Expert System Using the Educational Game to Determine Children's Autism Levels Using Forward Chaining

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***Abstract*---**Educational games for autistic children are learning media specifically for autistic children, both in terms of themes, appearance, curriculum, and so on. So that the game can be played by the autistic child, it is necessary to adjust the difficulty level of the game with the child's level of autism. To determine the type of developmental disorder in children, an expert system can be used. The research method used in this research is the research and development method. The material applied to this educational game is reading and counting material for autistic children. Users of educational games that implement this expert system are SDLB students in grades 2-3 and SDLB teachers. Determining the level of autism in children based on educational games using the forward chaining method is quite

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accurate in detecting the level of autism in children based on their cognitive abilities.

***Keywords*---**autism, education, expert system, forward chaining, games.

Introduction

Education is a learning process from not knowing to knowing. Currently, almost all aspects of education have been digitized. However, there are still shortcomings in digitalization, one of which is education for autistic children. This is because in teaching children with autism, a special way is needed so that the child likes the learning process and is able to understand it. Educational games are a tool so that someone can learn through game media or computer games. Educational games for autistic children are learning media specifically made for autistic children, both in terms of themes, appearance, curriculum, and so on. To make the game playable by the autistic child, it is necessary to adjust the difficulty level of the game with the child's level of autism (Turkoglu et al., 2002; Liao, 2005).

Autism is a complex developmental disorder that causes barriers to social skills, communication, and behavior. The disorders range from mild to severe (Cekici & Sanlier, 2019). Autism consists of 3 categories, namely mild autism category has an IQ of 50-70, moderate autism category has an IQ of 35-50, and severe autism category has an IQ of 20-35 (Eaves & Ho, 2004). Based on this statement, at least 3 different levels of difficulty must be made in educational games that will be made by researchers so that autistic children can learn and play according to their autistic level. However, to determine how big the level of autism is, it is necessary to understand the things that affect the level of autistic children. In children with mild autism when given a mild sensory stimulus there is an immediate reaction, in children with moderate autism when given a strong sensory stimulus there is a little reaction, whereas in children with severe autism when given a strong sensory stimulus they do not respond at all (Eaves & Ho, 2004).

To determine the type of developmental disorder in children, an expert system can be used. An expert system is a computer program that imitates the thought processes and knowledge of experts in solving a particular problem. There are two approaches to control inference in a rule-based expert system, namely backward chaining and forward chaining (Al-Ajlan, 2015). Research conducted by Hays et al. (2020), they analyzed and designed an expert system to diagnose the characteristics of children with special needs using the forward chaining method. This study aims to make the school able to determine which major do the autistic children might enter using the system that has been created. In addition, research conducted in Pioggia et al. (2007), an android-based system to diagnose autistic disorders in children has been done (DeQuinzio et al., 2008; Aráoz, 2000).

Methodology

Research method

The research method used in this research is the research and development method, or commonly called Research and Development (R&D). This research method was chosen because it is the method used to produce a product and then test the effectiveness of the product (Scruggs et al., 2006). There are 10 stages in R&D research, namely Gall et al. (1996):

- Research and information collecting
- Planning
- Developing preliminary form of product
- Preliminary field testing
- Main product revision
- Main field testing
- Operational product revision
- Operational product testing
- Final product revision
- Dissemination and distribution

Based on the R&D research method, further adjustments were made to the research design according to the research needs such as the research flow in Figure 1.

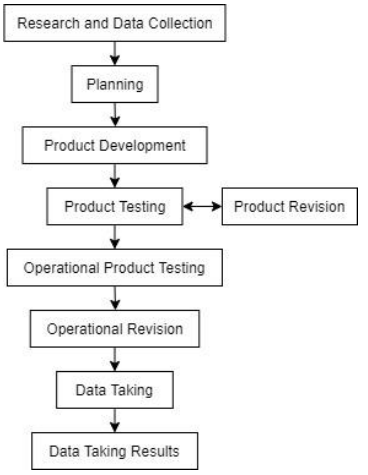

Figure 1. Research design

Research participants and location

The participants for this study were students from Special Schools in grade 2 or 3 at the elementary school level. The research was conducted at SLB C Bina Asih Cianjur and SLB BC Purnama Cipanas (Werdistira & Purnama, 2020; Danchikov et al., 2021).

Research population and samples

To determine the sample to be used, the researcher uses a purposive sampling technique, where sampling is based on certain considerations (Scruggs et al., 2006). The purpose of consideration in this study is to determine several criteria that will be used as research samples. Samples that meet the required criteria are samples that will later be used in research. The following are the criteria needed for this research:

- Students who are categorized as autistic are autistic children in grade 2 and or grade 3 of elementary school.
- Students from SLB C Bina Asih and SLB BC Purnama Cipanas with 2 participants from each of the schools.

Data analysis

Pre-field analysis

The researchers conducted data analysis before entering the field. The analysis was carried out by previous researchers and was based on preliminary study data through research results that were compiled in national and international journals to determine the focus of the research. Furthermore, the expert validation instrument data analysis was carried out using a rating scale. The rating scale calculation is determined by the formula Scruggs et al. (2006):

$$P = \frac{data\ collection\ result\ score}{ideal\ score}\ x\ 100\% \quad (1)$$

Where P is the percentage number, and the ideal score is the highest score times the number of respondents times the number of items. The validity level of the learning media in this study was determined into four categories using the scale in Figure 2.

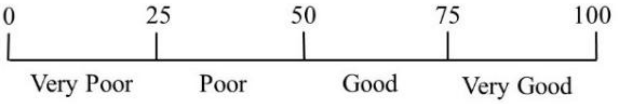

Figure 2. Validity result category interval

Field analysis

The data analysis used by the researcher is the Miles and Huberman model, which is a model where data components and presentation are carried out simultaneously with the data collection process. After all the data is collected, the data reduction, data presentation, and conclusion drawing will interact with each other (Kohlberg & Neyman, 2018; Radford, 2000). The steps of analysis using the Miles and Huberman model can be seen in Figure 3.

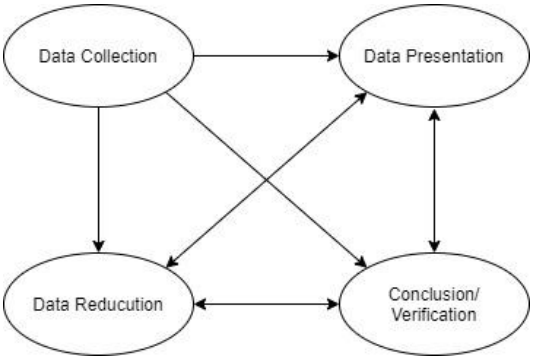

Figure 3. Interaction model data analysis components

- Data Collection: Data collection was carried out by searching for the required data on the data types and forms in the field, then recording the data in the field. In this study, researchers collected data in several places, namely SLB C Bina Asih Cianjur and SLB BC Purnama Cipanas.
- Data Reduction: Data reduction is summarizing, determining the main points, focusing on the main things, looking for themes and patterns, and discarding what is not needed (Scruggs et al., 2006). Therefore, the data that has been summarized will provide a clearer picture so that it can make it easier for researchers to carry out further data collection if needed.
- Data Display: After the data is reduced, the next step is to present the data. In presenting data, data can be linked in a structured manner, making it easy to understand. In qualitative research, data presentation can be done in the form of short writing, charts, flowcharts, and the like. By presenting this data, it will be easier to understand what happened during the research process.
- Verification: The last step is drawing conclusions. This conclusion is based on data reduction which is the answer to the problem raised in the study.

Result and Discussion

Research and data collection stage

At this stage, analyzes were carried out regarding the requirements for software development such as material requirements, target users, software requirements, and hardware requirements (Psacharopoulos, 1994; Robinson & Sexton, 1994).

Material needs analysis

The material applied to this educational game is reading and counting material for autistic children. Reading has a very important role in human life, as it is helpful to help humans obtain and understand various information. An element that must exist in every reading activity is understanding. Reading is the process of picking and understanding the meaning contained in written language (Rosenblatt, 2018). Basically counting is necessary as it helps to know the names of numbers and sequences of numbers while understanding the correspondence of one by one (Greer & Erickson, 2019). In developing an understanding of numbers, students with significant cognitive disabilities need understanding,

practice, and the opportunity to re-understand numbers several times through repetition and variation (Greer & Erickson, 2019). The material applied was related to observing descriptive texts and recognizing 1 to 10 numbers, and adjusted for abilities at the autistic level as follows De Urturi et al. (2011):

- Mild
  - Still able to read, write, and do simple counting.
  - Slightly difficult in doing abstract thinking.
- Moderate
  - Unable to do abstract thinking
  - Only able to read single sentences
  - Having counting difficulty
- Severe
  - Completely unable to do abstract thinking
  - Only able to read single words

Table 1 shows the basic competencies and indicators used.

Table 1
Basic competence and indicator

Subject Matter	Basic Competence	Autism Level	Indicator
Reading	Observing simple instructional text /directions about the surrounding environment in Indonesian, both spoken and written, assisted by local language vocabulary	Mild	• Students are able to listen to instructional text/direction • Students are able to read instructional text/direction • Students are able to show fruits in the instructional text/direction
		Moderate	• Students are able to listen to simple instructional text/direction • Students are able to read simple instructional text/direction • Students are able to show fruits in the instructional text/direction
		Severe	• Students are able to listen to simple instructional text/direction • Students are able to show the name of the fruit according to the provided fruit
Counting	Recognizing	Mild	• Students are able to

natural numbers up to 20 using concrete objects		recognize natural number from 1 to 10 • Students are able to count the number of fruits based on natural numbers from 1 to 10 • Students are able to show the natural numbers from 1 to 10
	Moderate	• Students are able to recognize natural number from 1 to 5 • Students are able to count the number of fruits based on natural numbers from 1 to 5 • Students are able to show the natural numbers from 1 to 5
	Severe	• Students are able to recognize natural number from 1 to 5 • Students are able to count the number of fruits based on natural numbers from 1 to 5 • Students are able to show the natural numbers from 1 to 5
Knowing the concept of adding two numbers which result is up to 20 using concrete objects	Mild	• Students are able to add up 2 different types of fruit which results up to 10

User's analysis

Users of educational games that implement this expert system were special elementary school students in grades 2-3 and special elementary school teachers. Students here were the direct users in playing this educational game, while the teachers here were the indirect user because the teachers might use or take advantage of this educational game as an alternative in teaching children with autism.

Planning stage

This stage was the initial planning in the form of an initial description of the software that will be made using use case diagrams and its scenarios, as well as sequence diagrams.

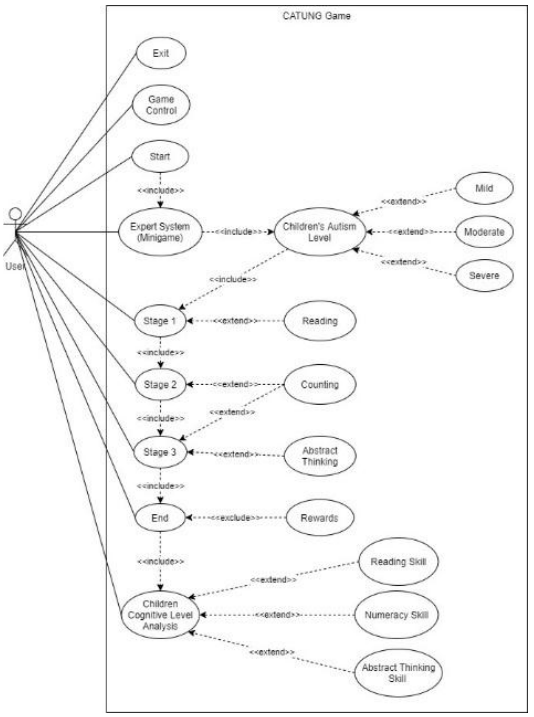

Figure 4. Use case diagram

Table 2 below is the use case scenario of each use case in Figure 4.

Table 2
Use case scenario

User	System Response
1. The user opens the program	
2. The user presses on start button	
	3. The system displays mini game page
4. User works on mini game challenges	
	5. The system analyses user's level of autism using the forward chaining method
	6. The system determines the game level according to the user's autistic level
	7. The system displays the stage 1 page of the main game

User	System Response
8. The user works on challenge in stage 1	
9. The user completes the challenge in stage 1	
	10. The system displays rewards in the form of stars and keys to open the door to the next stage
11. The user points the key to the door in the game using the mouse	
	12. The system opens the door to the next stage
13. The user presses the arrow keys on the keyboard	
	14. The system moves the character in the game according to the direction of the arrow pressed by the user
	15. If the character passes through the door to the next stage, the system will close the door and the system will move the camera to the next stage
16. The user works on challenge in stage 2	
17. The user completes the challenge in stage 2	
	18. The system displays rewards in the form of stars and keys to open the door to the next stage
19. The user points the key to the door in the game using the mouse	
	20. The system opens the door to the next stage
21. The user presses the arrow keys on the keyboard	
	22. The system displays rewards in the form of stars and keys to open the door to the next stage
	23. If the character passes through the door to the next stage, the system will close the door and the system will move the camera to the next stage
24. The user works on challenge in stage 3	
25. The user completes the challenge in stage 3	
	26. The system displays the reward in the form of stars
	27. The system displays the end page and also the total reward obtained
28. The user presses the analysis button	

User	System Response
	29. The system displays a page of children's reading, counting, and abstract thinking skills analysis.

Sequence diagram

Sequence diagrams were used to describe interactions or a series of messages between objects. Figure 5 is a sequence diagram in this software.

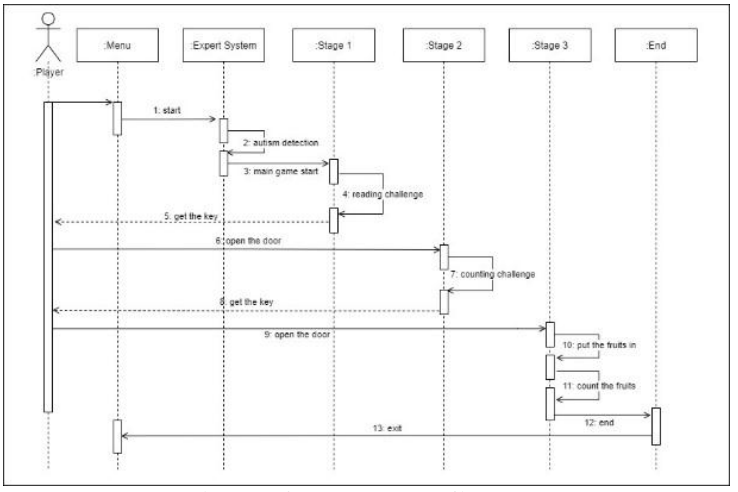

Figure 5. Sequence diagram

At the beginning of the use of the software, the player will access the menu, then press the start button and enter the expert system. In the expert system, there will be a series of processes to detect the level of autism. After going through the process in the expert system, players will then enter the main game. In this main game, players will firstly enter stage 1. In stage 1, players will be given a series of challenges in the form of reading challenges. After completing the challenge, players will get a key to open the door to stage 2. After the door is open, players can enter stage 2. In stage 2, players will be given a series of challenges in the form of counting challenges. After completing the challenge, players will get a key to open the door to stage 3. After the door is opened, players can enter stage 3. In stage 3, players will be given a series of challenges in the form of counting challenges and abstract thinking. After completing the challenge, they will enter the finished view. After that, the player can return to the menu (Marsh et al., 2013; Ristic et al., 2005).

Product development stage

In this research, the method used in developing the software is the DDD-E (Decide, Design, Develop, and Evaluate) method.

- Decide stage
  The educational game model for autistic children can be seen in Figure 6.

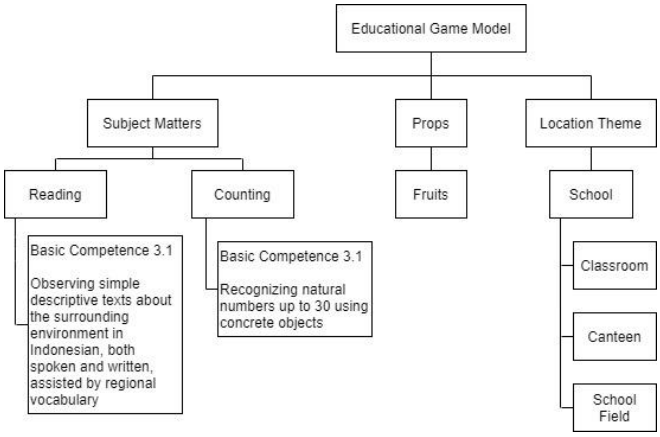

Figure 6. Educational game model scheme

- Object: The objects selected in this research were students with special needs with autism in grades 2 and 3 at the Elementary School level. The place of research conducted by researchers is SLB C Bina Asih Cianjur and SLB BC Purnama Cipanas.
- Props: The props used in this educational game are apples and bananas. The props in question are in the form of 2D images and 3D objects. The images and objects used are objects that correspond to objects around everyday life (De Urturi et al., 2011).
- Location Theme: In this educational game that will be made, the school's theme is the determined location. Furthermore, this theme will be divided into three rooms or stages; in the classroom, canteen, and schoolyard.
- Literature: Autism is an overall developmental disorder that causes social skills, communication, and behaviour barriers. The disorder ranges from mild to severe (Cekici & Sanlier, 2019). Classifying autism in this educational game is using an expert system with the forward chaining method. An expert system is a computer program that simulates the thought process and expert knowledge in solving a particular problem. The realization of expert systems is widely used in psychology because expert systems are considered a way to store expert knowledge in certain areas of computer programs so that decisions can be made in intelligent reasoning (Al-Ajlan, 2015). Forward chaining is a search method or forward tracking technique that starts with existing information and combines rules to form a conclusion or goal (Riza et al., 2017; Cahyadi & Riza, 2016).

- Design Stage
  - Character and Object

Figure 7. 3D Boy design

Figure 8. 3D Apple design

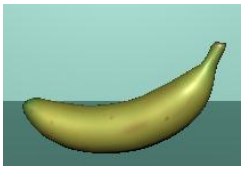

Figure 9. 3D Banana design

Sequence diagram

The sequence diagram can be seen in Figure 5.

- Develop Stage
  - Main Menu Display

Figure 10. Main menu design

- Expert System Mini-Game Display: The mini game contains an expert system that will detect a child's level of autism based on their cognitive abilities. In Figure 11, the system will test autistic children to read

simple sentences and think abstractly. Moreover, in Figure 12, the system will test autistic children to count and read one word. An expert system will process the results of these tests, and it can be determined what level of autism the child is based on his cognitive abilities.

Figure 11. Mini game: put fruits in

Figure 12. Mini game: counting banana

- Game Display: Figure 13 shows the challenge in stage 1 in the form of reading. At this stage, instructions will be given in the form of writing or sound depending on the level of autism and the choice of a fruit that must be touched or multiple choices on the blackboard depending on the level of autism.

Figure 13. Stage 1 challenge display

Figure 14 is a display of the challenges in stage 2. In this section, the challenge given is counting. Instructions will be given in the form of audio. The challenges given can be 1 or 2 types of fruit depending on the level of autism.

Figure 14. Stage 2 challenge display

Figure 15 shows the challenges in stage 3. In this section, the challenges given are counting and abstract thinking. Instructions will be given in the form of audio. The first instruction is to put the fruit into the basket according to the instructions given, and then the next step is to count the fruit that has been inserted.

Figure 15. Stage 3 Challenge Display

Evaluate

At the evaluation stage, the Black Box testing method was used. Before carrying out the test, a test plan is needed first. The test plan is described in Table 3.

Table 3
Testing plan

No	Tested Items	Expected Results
1	In-game UI buttons	All buttons work according to their function
2	In-game narrator audio	The narrator's voice speaks according to the content being displayed
3	Audio effects on every object in the game	The sound of the object is following the characteristics and needs of the object
4	In-game drag and drop feature	This feature can pick up and move objects in the game
5	In-game answer options or choices	Options can be clicked according to the question
6	Character movement	Characters can be moved using the left and right arrows on the keyboard
7	In-game animation	Animation in line with the characteristics and needs of the object
8	In-game levelling	Level according to the output of autism level based on expert system
9	Expert system modelling	The expert system model is following the theory and can determine the level of autism according to the theory
10	Analysis of reading, counting, and abstract thinking skills	The system can analyze the player's reading, counting, and abstract thinking skills based on the games he has played
11	In-game rewarding system	The game can give rewards when players complete each challenge

This stage consists of several phases until the product is ready for operational testing.

- Phase 1

Table 4
Phase 1 blackbox results

No	Tested Items	Expected Results	Real Results	Test Results
1	In-game UI buttons	All buttons work according to their function	Each button can be clicked and is already functioning according to its function	Appropriate
2	In-game narrator audio	The narrator's voice speaks according to the content being displayed	The narrator's speech is following the content being displayed	Appropriate
3	Audio effects on every object in the game	The sound of the object is following the characteristics and needs of the object	The sound of the object is following what is being clicked or moved and following the characteristics and functions of the object	Appropriate
4	In-game drag and drop feature	This feature can pick up and move objects in the game	Objects using this feature can be picked up and moved using the mouse	Appropriate
5	In-game answer options or choices	Options can be clicked according to the question	Each answer option can be clicked and is in accordance with the answers to the existing questions	Appropriate
6	Character movement	Characters can be moved using the left and right arrows on the keyboard	Characters can be moved using the left and right arrows on the keyboard without any problems	Appropriate
7	In-game animation	Animation in line with the characteristics and needs of the object	The animation runs smoothly and is in accordance with the characteristics and needs of the object	Appropriate
8	In-game levelling	Level according to the output of autism level based on expert system	The displayed level is in accordance with the autism level output based on the expert system	Appropriate
9	Expert system modelling	The expert system model is following the theory and can determine the level of autism according to the theory	The expert system modeling is in accordance with the theory and can determine the level of autism based on the theory. However, there is still a gap if the player incidentally answer all the challenges in the expert system correctly	Not Appropriate
10	Analysis of reading,	The system can analyze the player's reading, counting,	The system has been able to analyze the ability to read, count,	Not Appropriate

No	Tested Items	Expected Results	Real Results	Test Results
	counting, and abstract thinking skills	and abstract thinking skills based on the games he has played	and think abstractly based on the game that he has played, but it is not explained in detail regarding the analysis results.	
11	In-game rewarding system	The game can give rewards when players complete each challenge	The rewarding system is only audio and stars at the end of the game. There should be a reward in the form of stars as well at each stage	Not Appropriate

Based on the results of testing using Blackbox in table 4, it is known that there are still features that are not appropriate. Furthermore, a product revision is carried out based on the test results. The following are the revisions made in this phase 1.

- Improved expert system modeling by looping commands three times to prevent players from answering correctly by incidental.
- Added a detailed explanation regarding the results of the child's cognitive abilities analysis based on the games he has played.
- Added reward system in the form of stars at each stage.

- Phase 2

Table 5
Phase 2 blackbox results

No	Test Items	Expected Results	Real Results	Test Results
1	In-game UI buttons	All buttons work according to their function	Each button can be clicked and is already functioning according to its function	Appropriate
2	In-game narrator audio	The narrator's voice speaks according to the content being displayed	The narrator's speech is following the content being displayed	Appropriate
3	Audio effects on every object in the game	The sound of the object is following the characteristics and needs of the object	The sound of the object is following what is being clicked or moved and following the characteristics and functions of the object	Appropriate
4	In-game drag and drop feature	This feature can pick up and move objects in the game	Objects using this feature can be picked up and moved using the mouse	Appropriate
5	In-game answer options or choices	Options can be clicked according to the question	Each answer option can be clicked and is in accordance with the answers to the existing questions	Appropriate
6	Character movement	Characters can be moved using the left and right arrows on the keyboard	Characters can be moved using the left and right arrows on the keyboard without any problems	Appropriate
7	In-game	Animation in line with the	The animation runs smoothly and	Appropriate

No	Test Items	Expected Results	Real Results	Test Results
	animation	characteristics and needs of the object	is in accordance with the characteristics and needs of the object	
8	In-game levelling	Level according to the output of autism level based on expert system	The displayed level is in accordance with the autism level output based on the expert system	Appropriate
9	Expert system modelling	The expert system model is following the theory and can determine the level of autism according to the theory	The expert system modelling is in accordance with the theory and has been able to determine the level of autism based on the theory	Appropriate
10	Analysis of reading, counting, and abstract thinking skills	The system can analyze the player's reading, counting, and abstract thinking skills based on the games he has played	The analysis obtained is in accordance with every possibility that can be done by players in every challenge that exists and is explained in detail	Appropriate
11	In-game rewarding system	The game can give rewards when players complete each challenge	The game already provides rewards at every stage and the end of the game. However, the reward given is still static, so the reward given will always be the same even though the player makes a lot of mistakes	Not Appropriate

Based on the test results using Blackbox in Table 5, it is known that there are still shortcomings in the rewarding system. Furthermore, a product revision is carried out based on the test results. The following are the revisions made in this phase 2.

- Make details on the rewarding system so that the stars obtained are different between those who answer the most correctly and those who answer the most incorrectly. If many players answer correctly, then the star obtained is one full star on that stage.

- Phase 3

Table 6
Phase 3 blackbox results

No	Test Items	Expected Results	Real Results	Test Results
1	In-game UI buttons	All buttons work according to their function	Each button can be clicked and is already functioning according to its function	Appropriate
2	In-game narrator audio	The narrator's voice speaks according to the content being displayed	The narrator's speech is following the content being displayed	Appropriate
3	Audio effects on every object in the	The sound of the object is following the characteristics and needs	The sound of the object is following what is being clicked or moved and following the characteristics and	Appropriate

No	Test Items	Expected Results	Real Results	Test Results
	game	of the object	functions of the object	
4	In-game drag and drop feature	This feature can pick up and move objects in the game	Objects using this feature can be picked up and moved using the mouse	Appropriate
5	In-game answer options or choices	Options can be clicked according to the question	Each answer option can be clicked and is in accordance with the answers to the existing questions	Appropriate
6	Character movement	Characters can be moved using the left and right arrows on the keyboard	Characters can be moved using the left and right arrows on the keyboard without any problems	Appropriate
7	In-game animation	Animation in line with the characteristics and needs of the object	The animation runs smoothly and is in accordance with the characteristics and needs of the object	Appropriate
8	In-game levelling	Level according to the output of autism level based on expert system	The displayed level is in accordance with the autism level output based on the expert system	Appropriate
9	Expert system modelling	The expert system model is following the theory and can determine the level of autism according to the theory	The expert system modelling is in accordance with the theory and has been able to determine the level of autism based on the theory	Appropriate
10	Analysis of reading, counting, and abstract thinking skills	The system can analyze the player's reading, counting, and abstract thinking skills based on the games he has played	The analysis obtained is in accordance with every possibility that can be done by players in every challenge that exists and is explained in detail	Appropriate
11	In-game rewarding system	The game can give rewards when players complete each challenge	The game already provides rewards at every stage and the end of the game. The rewards given are also in accordance with the abilities of the players at each stage	Not Appropriate

Operational product testing stage

The main test was conducted through a media expert validation test. The instrument used in testing this educational game refers to Multimedia Mania 2004. The game testing was conducted by two lecturers at the Department of Computer Science Education, they are Mrs. Andini who is a multimedia expert, and Mr. Erlangga who is an expert system expert. The test results are described in Table 7.

Tabel 7
Media expert validation test

No	Aspect	Criteria	Ideal Score	Scoring			Value	Sum	Total	Percentage (%)
				Mrs. Andini	Mr. Erlangga	Ave-rage				
1	Mechanism	Technical	16	4.0	4.0	4.0	x1	4.0	16	100
		Navigation		4.0	4.0	4.0	x1	4.0		
		Spelling and Grammar		4.0	4.0	4.0	x1	4.0		
		Completion		4.0	4.0	4.0	x1	4.0		
2	Multimedia Elements	Interface Design	8	3.5	4.0	3.75	x1	3.75	7.75	96.875
		Use of Enhancement		4.0	4.0	4.0	x1	4.0		
3	Information Structure	Organization	16	4.0	4.0	4.0	x2	8.0	15.5	96.875
		Branching		3.5	4.0	3.75	x2	7.5		
4	Documentation	Resources Citing	8	4.0	4.0	4.0	x1	4.0	7.0	87.5
		Resources Citing Permission		2.0	4.0	3.0	x1	3.0		
5	Content Quality	Originality	52	3.0	4.0	3.5	x3	10.5	48	92.31
		Curriculum Alignment		3.5	4.0	3.75	x3	11.25		
		Evidence that Objectives Were Met		3.5	4.0	3.75	x3	11.25		
		Content Depth & Breadth		3.5	4.0	3.75	x2	7.5		
		Subject Matter on the Media		3.5	4.0	3.75	x2	7.5		
								Final Score		94.712

Based on Table 7, it can be seen that the validation to determine the feasibility of multimedia from the aspect of mechanism is 100%, multimedia element aspect is 96.875%, information structure aspect is 96.875%, documentation aspect is 87.5%, and content quality aspect is 92.31%. On average, this software assessment score by media experts is 94.712%.

Operational product revision stage

At this stage the researchers changed several parts based on experts suggestions during operational testing, including:

- Removed the fruit option in stage 1 when the child has completed the challenge in stage 1 to prevent the chilled from staying in that stage.

- Changed the duration of instruction appearance in stage 3 which was too long so that autistic child will have no difficulty in understanding the instruction.

In addition to change the existing sections, there are additional features that were also suggested by the experts, including:

- Added an animation effect when the player has correctly answered the question or challenge.
- Added UI instructions to move the character to the next stage.

Data taking stage

After the software was declared as feasible by experts and improvements had been made based on the suggestions from experts, the next step is to take field data as explained previously. This stage contains the results obtained during data collection, data processing, and other reports related to data taking that has been carried out in the field. Table 8 is the result of the students' post-test and pre-test.

Table 8
Students pre-test and post-test result

No	Name	Class	Pre-test Result	Post-test Result
1	N	2	No question was answered	Correctly answered 1 question even though it took a little help to write the answer
2	G	3	Answered 1 question only	Correctly answered all questions even though it took a little help to write the answer
3	R	3	Answered 2 questions only	Correctly answered all questions
4	F	3	Answered 3 questions only	Correctly answered all questions

It can be seen from table 8 that almost all students get significant results before and after playing this educational game. It can be seen that student N did not get significant results, even there was no question answered at the pre-test because based on information from the teacher at that special school, student N was classified as severe autism in terms of cognitive. Then, student G was classified as moderate autism in terms of cognitive. Student R and F were classified as mild autism in terms of cognitive. The following is a table of suitability between information from the special school teacher and the expert system in the game related to the level of autism of these students.

Table 9
Suitability of students autism level between teachers and expert system

No	Name	Students' Autistic Level		Suitability
		Based on Teacher	Based on Expert System	
1	N	Severe Autism	Severe Autism	Suitable
2	G	Moderate Autism	Moderate Autism	Suitable
3	R	Mild Autism	Mild Autism	Suitable
4	F	Mild Autism	Mild Autism	Suitable

It can be seen from table 9 that the autistic level of students based on information from teachers in special schools has the same results as the detection results from the expert system using the forward chaining method. In addition, the researcher observed the students' emotional feelings. Researcher observed from facial expressions, movement responses, and vocal responses of students while using this educational game. The first assessment of emotional feelings was done by observing students when playing a mini game (a stage of the expert system). The results of these observations can be seen in table 10.

Table 10
Emotional feeling toward thr mini game (expert system)

No	Name	Emotion
1	N	Facial expression showed no excitement and tend to be frightened.
2	G	Facial expression tend to be flat, and less enthusiastic to do repeated instructions.
3	R	Quite excited at the beginning of the game, but getting bored to do repeated instructions.
4	F	Quite excited at the beginning of the game, but started to get bored as no reward was obtained in the mini game.

When the students played the mini game which is the analysis stage for the expert system, each student was tend to get bored and unmotivated because the same instructions were given repeatedly, there was no reward, and the environment was tend to be empty, only fruit and fruit boxes. Furthermore, the researchers observed the emotional feelings of students when playing the main game with levels that were set automatically based on the results of the expert system. The results of these observations can be seen in table 11.

Table 11
Emotional feeling toward the main game

No	Name	Emotion
1	N	Flat facial expressions but tend to be excited when playing the main game. Especially when the child got a reward in the form of stars and also when the audio said "Hore kamu berhasil! [Hurray you did it]". However, at the end of the game, the child cried and got annoyed when the total reward in the form of stars obtained during playing this game was only a little because the child's ability to answer each challenge was very lacking.
2	G	The child was quite excited to play the main game. Especially when the child got a reward in the form of stars and also when the audio said “Hore kamu berhasil! [Hurray you did it]”, the child shows a very happy expression to the point of clapping and saying “yeay”. Then at the end of the game when the total reward was quite perfect, the child showed a very happy expression to the point of clapping.
3	R	Facial expressions were very serious when playing the main game. Then when he got a reward in the form of stars and also when the audio said “Hore kamu berhasil! [Hurray you did it]”, the child showed a happy expression. Then at the end of the game when he got the perfect total reward, the child did not move from the laptop and wanted to play this educational game again.
4	F	Facial expressions were relaxed when playing the main game. Then when he got a reward in the form of stars and also when the audio said “Hore kamu berhasil! [Hurray you did it]”, the child showed a happy expression. Then at the end of the game when he got the perfect total reward, the child wanted to play this educational game again.

It can be seen in table 11 that while playing the main game, the students were excited and happy, especially when the rewards were given in the form of audio and visual. In addition, other additional environments that do not cause the display to feel empty make students not bored when playing this educational game are needed. At the end of the game, student N was angry and sad because he did not get many stars, but it was different from other students who were very happy because they got almost perfect and even perfect total stars. This proves that rewards are one of the important elements in a game so that the game could becomes fun (Riza et al., 2020).

Conclusion

Based on the results of the research that had been conducted in the expert system design for educational game to determine children's autism levels using the forward chaining method, it can be concluded that:

- Expert system design for educational game to determine children's autism levels using the forward chaining method, was using the Research and Development (R&D) method and DDD-E (Decide, Design, Develop, Evaluate) multimedia development model.
- The accuracy of the expert system in detecting the level of autism in children based on their cognitive levels can be seen in Tabble XI. The

suitability between the information from the teacher and the results obtained from the expert system are all appropriate. Hence, it can be concluded that the expert system design for educational game to determine children's autism levels using the forward chaining method is quiete accurate in detecting the level of autism in children based on their cognitive levels

- The rewarding systems in this educational game was found to be very influential on children's emotions when playing the game.

Futhermore, in the future, there are some machine-learning methods can be included to compute and determine children's autism levels, such as fuzzy sets Riza et al. (2015), rough sets Riza et al. (2014), natural language processing (Riza et al., 2016), and classifier methods (Alasker et al., 2017).

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