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Learning Game Application Development: Crime Scene Investigation (CSI)

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Abstract

Digital forensic learning media has been developed as a computer-based application. The development of game-based applications that can be used to improve cognitive learning outcomes has been tested over a period of time. The research was conducted using the ADDIE research and development method. The ADDIE method consists of five stages, namely analysis, design, development, implementation, and evaluation. The purpose of the study was to find out if this software has been successfully developed and whether it is a useful learning tool for digital forensics.

Keywords: *Learning game, Digital forensics, Crime scene investigation, Game application, ADDIE Model*

1. Introduction

Digital forensics refers to the practice of collecting, analyzing, and preserving electronic evidence where the procedure uses certain procedures to be accepted as evidence in court. The purpose of digital forensics is to conduct thorough and impartial investigations of digital devices, such as computers, smartphones, and servers, in order to uncover and document any evidence that may be relevant to a criminal or civil case. The process involves a combination of technical and legal expertise and involves the use of specialized tools and techniques to identify, extract, and analyze data from digital devices. Activities from digital forensics include analysis of data such as deleted files, emails and instant messages, social media posts, and web browsing history. Digital forensics is an important tool for law enforcement, companies, and legal professionals, as it provides a way to uncover and understand electronic evidence that is increasingly being used to support or disprove lawsuits [1]–[3].

Media has a very important role in achieving learning objectives. By using a variety of media in the classroom, students can become more engaged and less passive. Learning media is mandatory for use in all subjects, including digital forensics. To encourage students to spend more time studying, learning media must be packaged attractively. To overcome students' low interest in studying digital forensics, learning media is often chosen as a learning medium [4].

Digital forensics is an emerging and rapidly growing field. To be able to respond to the ever-increasing incidence of cybercrime, there is an increasing demand for digital forensics experts in today's, and future-proof, labor markets. The video-game industry, however, has neglected this field, as there are only a few titles that teach digital forensic skills and knowledge [5].

There is no doubt that computers are increasingly being used as a means of playing games, rather than video games. In studies, it has been shown that computer games are played by children as young as two as well as adults. In addition, students can learn more effectively and more fun when computer games are incorporated into the classroom [6].

Crime scene investigations are very important. It combines science, logic, and law. Crime scene investigation is a long and tedious process that involves documentation, photography, or videography that is useful both from the situation or conditions at the crime scene, as well as the position of the evidence. Gather physical evidence that could possibly explain what has happened and show how and who did it. There may be no

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general crime scene, no general evidence framework, and no typical approach to a police investigation. The crime scene investigation unit (CSI) handles the division between fieldwork and laboratory work differently. Not all crime scene investigators are forensic scientists. Crime scene investigators worked in the field but collected evidence at the crime scene and sent it to a forensic laboratory for further analysis and report writing [7]–[9].

The purpose of this paper is to introduce serious CSI game design for student purposes in digital forensics by using research and development methods as an ADDIE approach. CSI games are based on known game design models, but emphasize the inclusion of recent learning attributes that have been identified in serious game design research. The design and development of this crime scene investigation game-based learning media uses UNITY 3D and MakeHuman which are based on the C++ programming language. Based on surveys and observations by educators, we evaluated the educational properties of the game.

2. Literature Studies

In 1944, a group of mathematicians invented game theory. "The game consists of a set of rules that shape the competitive situation of two to several people or groups by choosing a strategy built to maximize one's own victory or limit the opponent's victory," wrote Oskar Morgenstern and John von Neumann. Rules determine the actions each player allows, the amount of information each player learns as the game progresses, and the number of wins or losses in a given situation [10]. The game itself is a great learning medium for developing logical thinking, mental effort, and patience [11].

"Game" can refer to many things, including physical games, video games, board games, card games, and more. Physical games refer to games played outdoors or in a physical environment, such as sports, playground games, or games involving physical activity. A video game is a digital game played on a computer or game console. They range from simple arcade-style games to complex and immersive role-playing games. A board game is a game played on a flat surface using pieces or cards, such as chess, chess, monopoly, and others. A card game is a game played using a deck of cards, such as poker, bridge, and solitaire. In general, games can be used for entertainment, competitions, or as a form of education.

There are already games on the topic of crime scene investigations, such as CSI: Crime Scene Investigations. In this game, players will take on the role of an investigation team along with other characters who will search various rooms at the crime scene in search of evidence. Each case in this game has a story, and there are five cases in all. The game features a narrator whose role is to describe the details of the game, and players use tools or equipment to investigate crime scenes to find evidence and question suspects. Players or investigators can ask questions and interrogate everyone involved, as well as some co-workers, to deal with the evidence and determine the alibi and motives of the suspect. The culprit is identified when all the evidence and findings of the interrogation match one of the persons involved in each case. After completing each case, players will receive a score of Evidence Collected, Clues Used, Total Cases, and Rank at the end of the game. If players can solve cases without resorting to any assistance, they will receive Collected Evidence = 100%, Clues Used = 0%, Total Cases = 100%, and Master Rank.

In addition to this game, there is also a one called Crime Scene Investigation 2. In this game, players will be tasked with solving murder and kidnapping mystery cases. They will work as a team of investigators to find the victims and perpetrators of murders and kidnappings. The objective of the game is to collect all the evidence from different corners of the room at the crime scene to get to the kidnapping site and also to find the perpetrator of the crime. The game can develop the player's thinking ability due to the presence of evidence that can be used to find further evidence, as well as the player's analytical ability because puzzles serve as a guide, and the player's accuracy because there

is invisible evidence. The game will end when all the evidence directs the investigation team to the location of the perpetrator and the perpetrator is arrested.

Figure 1 contains images and descriptions of two crime scene investigation games. Two games that are used as literature are CSI: Crime Scene Investigation (Game 1) and Crime Scene Investigation II (Game 2).

Figure 1. Review game crime scene investigation

In Indonesia, Crime Scene Investigation is the investigation of a crime scene (crime scene), also known as crime scene processing. The processing of crime scenes is included in the investigation stage of an incident, according to Article 12 paragraph (1) of Perkapolri 14/2012. That the meaning of investigation / investigation is determined in Article 1 Number 2 of the Criminal Procedure Code (KUHAP) on the legal basis of crime scenes (Case Cases), investigation is a series of investigative actions in terms of and according to the manner regulated in this law. law. search and collect evidence to establish the facts of the crime and find the culprit [12].

Various advances in the handling of crime cases involving digital technology must continue to be made. Many studies have been conducted on the digital forensic investigation process model since 1984. In this section, we will look at one of NIST's

digital forensic investigation models. According to NIST, the investigation model has four stages:

a) Evidence Collection: involves the placement of related information, after which the data is sorted according to the priority and level of trust of the information.
b) Evidence Preservation: a data storage procedure that has been completed at the stage before this is performed, then prepared to proceed to the stage after this.
c) Evidence Analysis: analyzing the data collected at the previous stage is the main procedure in computer forensic investigation. This stage includes determining the source of the crime, the motivation for the crime, and finally the person responsible for the crime.
d) Evidence Presentation: after the analysis is completed, the next step is to give a presentation to the relevant authorities about the findings that have been obtained. The conclusions of the analysis not only need to be given at this stage, but also need to be supported by sufficient/qualified and acceptable evidence. This step is very important, considering that both of these requirements must be met. The purpose of this stage is to establish or deny the defendant's conduct [13].

3. Research Methodology

Research and development is used to develop educational games for crime scene investigations. This method is referred to as the ADDIE method. The ADDIE framework is intended to assist in the design and development of application programs. There are several stages in the ADDIE process, including Analyze, Design, Development, Implementation, and Evaluation [14].

3.1. Analysis

As part of the educational game design process, this stage begins with identifying the problem and analyzing the needs. As a summary, the identification of problems at the analysis stage is: (1) lack of focus from students; (2) the need to learn interactively and engagingly; (3) learning applications; (4) system design; (5) implementation.

The needs analysis is divided into three parts, namely: analysis of input, process, and output needs. The description related to the results of the needs analysis is summarized in Table 1. Meanwhile, in the analysis of software needs, the windows 10 Home, Unity 3d, and MakeHuman operating systems are needed. Furthermore, the analysis of interface needs includes: loading page, start menu, start investigation, and map.

Table 1. Requirement of system

System Needs Analysis		
Input	**Process**	**Output**
Text, graphics, sound, and effects	Hint search process, investigation process, investigation process of found devices	Images of figures and objects, story sequence, backing sounds and effects

3.2. Design

In designing this crime scene educational game, five stages were carried out, namely (1) the concept of assets and storyboard games; (2) HIPO diagram design; and (3) the design of activity diagrams and interfaces. The list of assets used on this gaming app is: images, audio, text and fonts, and character designs. One of the created character designs is shown in Figure 2.

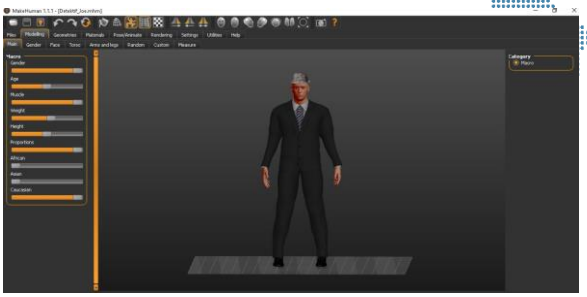


Figure 2. Detective Joe's character design

The next thing you need to do is figure out the overall flow of the game. The plot is developed according to the drawn storyboard. The plot follows the sequence of events that occurred during the digital forensic investigation, which includes evidence collection, evidence preservation, evidence analysis, and evidence presentation. When a user signs in for the first time, they'll be taken to the main menu page. On this page, there are four buttons available to choose from: play the game, options, load the game, and exit. The system will then take the user to the game's main page or game page after they press the game play button. Figure 3 illustrates an example of a single task that can be completed during a storyboard.

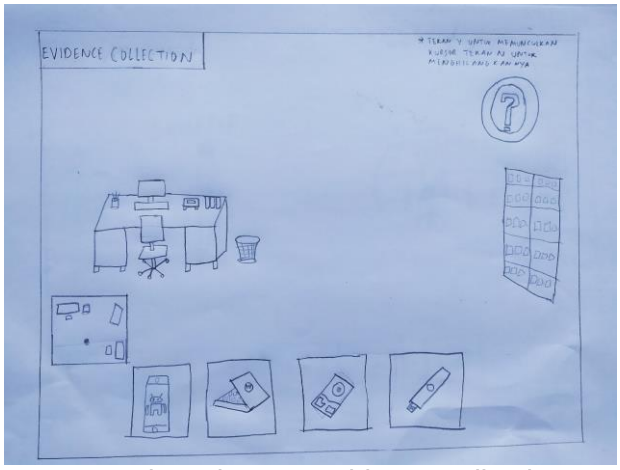


Figure 3. Storyboard scene evidence collection page

The construction of a game begins with the design of gameplay. The Hierarchy Plus Process Input Output (HIPO) chart here is used to give an idea of the system being built. HIPO is a package that provides a set of diagrams that graphically depict the functioning of a system from a general level to a specific level. This diagram starts from the top level and continues down. First, each main function is selected, and then it is subdivided into more layers. IBM is a company that developed HIPO. Figure 4 illustrates the overall layout of the HIPO diagram.

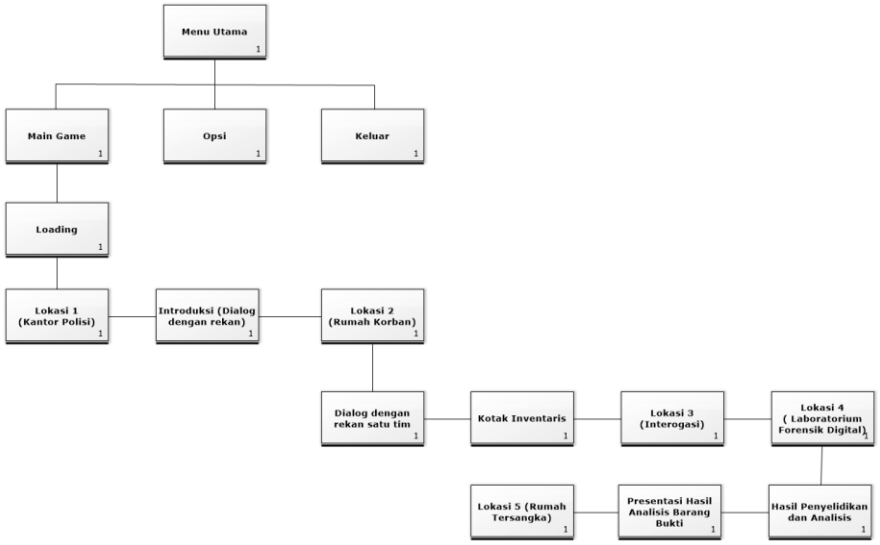


Figure 4. Storyboard scene evidence collection page

Using the activity diagram shown in Figure 5, one can create a game app summary for crime scene investigation.

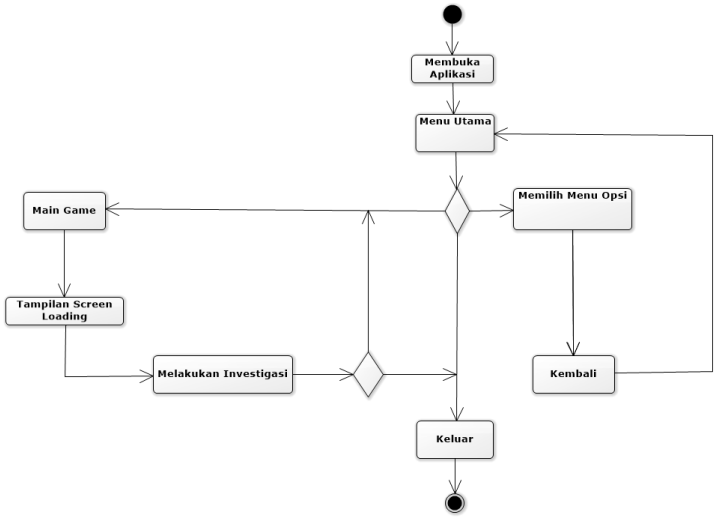
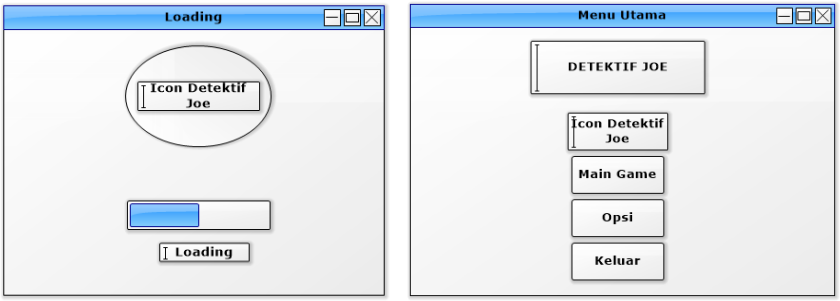


Figure 5. Activity diagram

At the final stage of designing the interface. Some of the interface designs shown in Figure 6 are: loading page, main menu page, game play page, options page, evidence check page, and credits page.



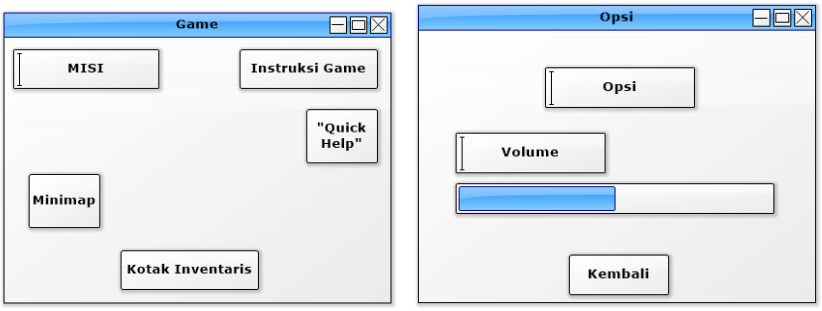


Figure 6. Interface design

3.3. Development

Creating a game based on a crime scene check requires creating graphics for the game as well. The creation of this graph takes the form of modeling. The modeling work performed not only models the people in the game, but also the locations where the game takes place, inventory boxes, and buttons. Make human and Unity3D are two programs used in the modeling process.

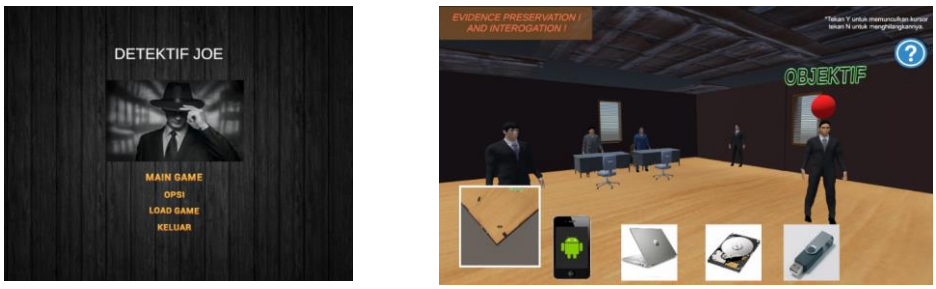
At this stage, modeling of the background of the place, investaris box, button, minimap, quick help, and figures is created. The appearance of one of the modeling is shown in Figure 7.

(a) **(b)**

Figure 7. (a) Quick help modelling (b) Button modelling

3.4. Implementation

The interface pixel size uses a pixel size of 1280 x 720. Implementation of game interface results for crime scene investigations includes: (1) implementation of the main menu, (2) loading of screen pages, (3) implementation of pages that appear when the game starts playing, and (4) implementation of credit pages, which include information about the individuals responsible for creating and compiling the game for this crime scene investigation. In the implementation stage, there are two parts, namely the main page, the game play page, and the credits page. Some implementation results are shown in Figure 8.



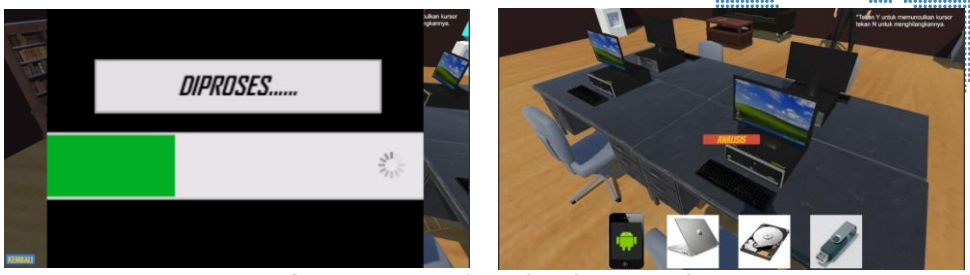


Figure 8. Interface implementation

3.5. Evaluation

The results of application testing are obtained in one way, namely by applying the Likert Scale calculation method and distributing questionnaires to respondents. The test results of the application are then analyzed. The respondent will be given a questionnaire that has eight questions in it, and the purpose of this question is to collect information about the correctness, suitability and performance of the application in relation to the concept of the proposed investigation.

Five students from Universitas Islam Indonesia, including many students majoring in digital forensics, participated in the test. When all the questions on the questionnaire have been answered by the respondents, they will be sent for processing so that the results can be obtained. A score will be given for each response given by the five respondents on the questionnaire. This will make the process of calculating the results of the questionnaire simpler. The following is a list of weighted values:

a) Value 1: Disagree
b) Value 2 : Quite Agree
c) Value 3 : Strongly Agree

The Likert scale is a psychometric scale commonly used in research that uses questionnaires. It is the most widely used approach to scaling responses in survey research, so the term is often used interchangeably with the rating scale, although there are other types of rating scales [15]. This score is the ideal score used to calculate the score to determine the scoring scale and the overall number of answers. The following formula is used to achieve an overall perfect score (criteria) for all items:

Kriterium Score = Scale Value x Number of Respondents (1)

Table 2. Criterion

Formula	Scale
1x5=5	Disagree
2x5=10	Simply Agree
3x5=15	Very Agree

In testing the system by the user, there is a questionnaire whose questions are described in Table 3 as follows:

Table 3. Questionnaire question

No.	Feature
1	The suitability of the application design to game-based learning media with the theme of the investigation process at the crime scene.
2	Gameplay that corresponds to the digital forensic investigation process.
3	Conformity of the sequence of crime scene investigations to criminal cases.
4	The investigation process follows the rules of digital forensics.
5	The flow of clues in directing evidence.

No.	Feature
6	The use of digital forensics laboratories in analyzing clues from the results of the investigation process.
7	The search for clues that are precisely hidden in the evidence.
8	The game display represents a criminal crime scene.

Based on the questionnaire in Table IV, the frequency of answers can be displayed in the form of a barchart for each question. A summary of the question results is illustrated in Figure 9.

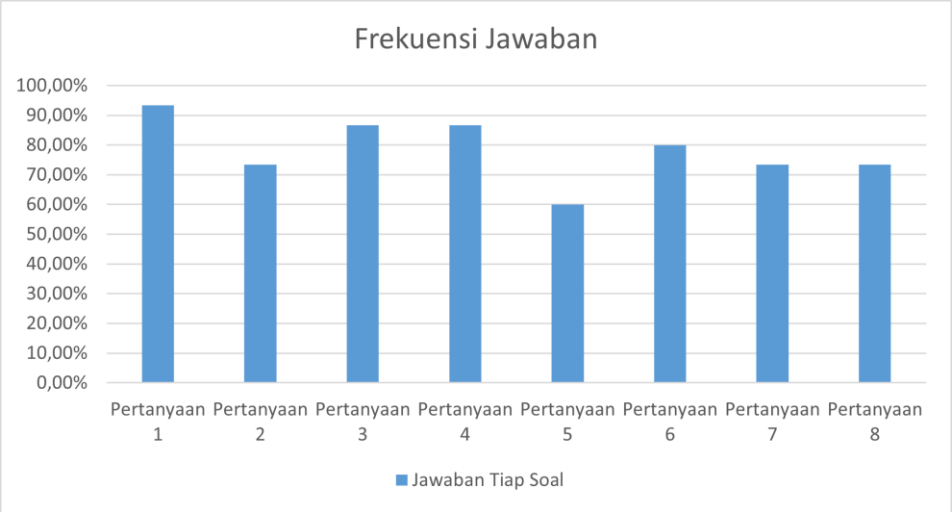


Figure 9. Bar chart of the frequency of answers to each question

Based on the barchart analysis carried out, there are evaluation components of these questions, such as the aspects that respondents think are the best and the aspects that respondents think are the least good. These components can be divided into the following categories:

a) According to respondents, the aspect that was considered the best was the application design aspect as a crime scene-themed learning medium because it was in accordance with the game displayed so that it resulted in a percentage value of 93.33 obtained.
b) The reason for the high rating is because the application design aspect is a learning medium with the theme of processing crime scenes.
c) According to the respondents, the aspect that was judged to be unfavorable was the aspect of the availability of clues that directed the investigation from the evidence to the subsequent evidence because it did not correspond to the displayed game so that a percentage value of 60% was obtained. This is because respondents argue that the existence of clues should direct the investigation from evidence to further evidence.

Use the formula for calculating the first, median, and third quartiles on the Likert scale before getting the total score to determine respondents' attitudes towards the app. This will make it possible to determine the value of the rating scale and its interval distance from the value in Figure 10. The application test was given to five respondents who were postgraduate students majoring in Informatics at UII. These students are between 20 to 30 years old and consist of men and women. Respondents were given a questionnaire based on 8 questions.

The results of Table 4 calculations from the respondents' questionnaire data are as follows:

Table 4. Data questionnaire respondents

Information	Sum
Respond	5
Question	8
Lots of Options	3
Lowest Value	1x8 = 8
Top Rated	3x8 = 24

Then the rating scale value can be generated along with the interval distance which can be shown in Figure 10 as follows:

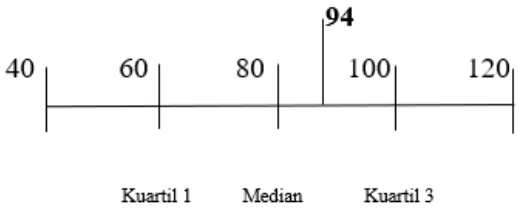


Figure 10. Rating scale values

Based on the percentage calculation above, the results are obtained with the following scale shown in Table 5.

Table 5. Percentage table

Answer Scale	Result = Answer Scale * Scale Value
Disagree	5
Simply Agree	32
Very Agree	57

The total number of results is 94, which can be inferred from the fact that the percentage calculation and answers are presented in table IV. The final score is 94, and we can enter the number into a predetermined rating scale to get the result and position, which is shown in figure 8. If entered, it indicates that the score is 94 out of 100 on the CS scale (Simply Agree).

It is recognized that the answer is 94 based on the results of the answers to the questions described earlier. The result of using the score (94:120)*100% to calculate the percentage of answers was 78.33%. Based on this percentage, it shows that crime scene processing games are suitable for use as a learning tool and training media in processing crime scenes according to digital forensic rules for graduate students of the Informatics Study Program, Universitas Islam Indonesia.

4. Results and Discussion

The evaluation is carried out based on the procedures that have been carried out to determine whether or not the game development objectives for this crime scene investigation are achieved. Here's a description of the investigation that was carried out when the crime scene investigation game was developed:

4.1. Achievement of goals and solution of the problems

The gaming app includes gameplay and detective work with varying degrees. Crime scene investigation game application development efforts have gone through several stages, starting with the analysis process, followed by modeling or designing, implementing, and testing the application. In the section titled "Implementation Results",

you will be able to examine the results that have been achieved, as well as the results that have been achieved by creating the game. This result has been achieved by including the three points of investigation that have been discussed earlier. The goal of effectively creating, modeling and building gaming applications on the topic of crime scene investigation has been achieved thanks to this.

4.2. Implementation process

The implementation stage is carried out when the design process is appropriate, but it does not rule out the possibility that there are problems and technical obstacles that arise during implementation. Technical problems and constraints include the following:

a) The game process tends to be slow because in game creation a lot of image items are needed, which means the storage required must also be quite large.
b) The movement of the player's angle of view is still considered too fast and less smooth, making it difficult for users who want to better control their angle of view.

There are bound to be restrictions imposed on even the most advanced gaming software. After that, an analysis was carried out by comparing video games that had comparable themes to identify these obstacles. CSI: Crime Scene Investigation is a game that has a similar theme to the game and is considered high quality, according to an analysis comparing the two games. Reviews of this CSI game can be found in previous study areas that are very similar to this one. Table 6 provides a comparison between CSI video games and games that have been developed specifically for crime scene inspections.

Table 6. Game comparison

No.	Comparison	*Game* CSI	App CSI Learning Game
1.	For the purposes of subsequent investigations, there is a process that includes the search and collection of clues, information, evidence, and the identity of suspects and witnesses/victims.	Available	Available
2.	There are methods that involve the search for a connection between a suspect, evidence, and witnesses or victims of a crime.	Available	Available
3.	During the investigation process, many puzzles and instruments were used.	Vary	Less varied
4.	Interaction, player type, and number of players all play a role in this game.	Interactive, Offline, *games* Single player	Less Interactive, Offline, *games* Single player
5.	Visual depiction of the location where the crime was committed.	Complex	Simple

Based on the comparison in Table VI, it can be seen that some of the limitations of the games that have been made are the lack of variety of puzzles and tools used during the investigation process, that is, games based on interaction are still less interactive, and the representation of crime scenes in pictures is still very simple.

5. Conclusion

The crime scene investigation game application that has been created successfully models the investigation process. This includes the search for digital evidence, clues, and

witness statements, as well as the stage of examining, analyzing, and processing digital evidence that has been found to draw conclusions about who the perpetrators are in the case of the crime that occurred. If you want to really process crime scenes, especially processing digital evidence, then the crime scene processing game application that has been developed effectively can be used as a training medium. Based on the tests and questionnaire results, it can be concluded that this gaming application has been operating effectively and as expected.

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