

## Development of Learning Material using Gamification for Students with Autism Spectrum Disorder

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**Abstract:** The basic need for students with an autism spectrum disorder in lectures is repetition in their learning activities. The development of gamification for learning material can accommodate these needs. Information System Department, Universitas Komputer Indonesia, has developed multimedia-based learning material with the concept of gamification for them in two courses as prototypes. Data for the needs for developing learning material was carried out through forum group discussions with experts in the education field for students with special needs. When data is collected from stakeholders, then analyzed with the Strength, Weakness, Opportunity, and Threat model to get a description of the internal and external environment in their learning process. After that, the design, development, and testing (using the black box method and user acceptance testing) of the multimedia application are presented. The result is an application as a prototype which is packaged in a gamification concept to provide interactive audiovisual through the provision of theoretical and practical material video and evaluation by the completion of a mission in a game. The goal is to efficiently deliver material in the learning process for them. The impact of the prototype can be able to improve the quality of the learning experience of students with an autism spectrum disorder.

**Abstrak:** Kebutuhan dasar mahasiswa dengan sindrom *autism spectrum disorder* dalam perkuliahan adalah melakukan repetisi dalam kegiatan belajar. Pengembangan gamifikasi pada materi pembelajaran dapat mengakomodasi kebutuhan mereka. Program Studi Sistem Informasi, Universitas Komputer Indonesia telah mengembangkan materi pembelajaran berbasis multimedia dengan konsep gamifikasi dalam dua mata kuliah sebagai prototipe. Data kebutuhan pengembangan materi pembelajaran dilakukan melalui *forum froup discussions* dengan para ahli di bidang pendidikan siswa berkebutuhan khusus. Ketika data dikumpulkan dari pemangku kepentingan, kemudian dianalisis dengan model *Strength, Weakness, Opportunity, dan Threat* untuk mendapatkan gambaran tentang lingkungan internal dan eksternal dalam proses pembelajaran. Setelah itu dilakukan perancangan, pengembangan, dan pengujian (menggunakan metode *black box* dan *user acceptance testing*) aplikasi multimedia. Hasilnya adalah sebuah aplikasi sebagai prototipe yang dikemas dalam konsep gamifikasi untuk menyajikan audiovisual interaktif melalui pemberian video materi teori dan praktek serta evaluasi penyelesaian misi dalam sebuah permainan. Tujuannya untuk menyampaikan materi secara efisien dalam proses pembelajaran bagi mereka. Dampak dari prototipe tersebut mampu meningkatkan kualitas pengalaman belajar mahasiswa dengan *autism spectrum disorder*.

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**INTRODUCTION**

Students with special needs with the Autism Syndrome Disorder (ASD) category have several difficulties in learning. They tend to become tantrums, apathetic, or reluctant to learn because of emotional changes that are sometimes uncontrollable. On the other hand, based on the admission of parents of ASD students and lecturers who teach subjects, the implementation of learning is often repeated several times until they can understand and memorize the material. For them, ideally, the material should be interesting with the equivalent of audiovisual, multimedia, or interesting and interactive games (gamification) through the use of technology to encourage them to learn (Raed, 2018; Goswami, Arora, & Ranade, 2021; Simões-Silva, et al., 2022; Pradiante, 2022; Darman, 2023). This certainly motivates and has a positive impact on the achievement of these students during the learning process in education. Many researchers reveal that gamification in science lessons has an impact on meaningful improvement in students' problem-solving skills, and learning experience and allows for collective knowledge building (Şahin & Namli, 2016; Majuri, Koivisto, & Hamari, 2018; Barghani, 2020; Najjar & Salhab, 2022; Pei & Harun, 2023). The willingness of gamers to play for hours, to try at a task and fail and still try again, that sense of fun at accomplishing something difficult and bringing it into their learning. Games, after all, are remarkably motivating and engaging; problem-solving, collaboration, and communication utilize several mechanisms to encourage people to engage with them, often without any reward, just for the joy of playing and the possibility of winning. Gamification contributes positively to the learning experience based on the information presented on curriculum availability (Ribeiro, Silva, & Mussi, 2018; Kotob & Ibrahim, 2019; Legaki, Xi, Hamari, Karpouzis, & Assimakopoulos, 2020; Yusril, et al., 2022). That is why the gamification concept to concern in education for extending learning material can motivate students' learning.

Basically, it takes design principles, game mechanics (like points, levels, badges, or leaderboards), gamification context, implementation, and evaluation to embody the application of gamification (Morschheuser, Hassan, Werder, & Hamari, 2018; Pham, 2020; Krath, Schürmann, & Korflesch, 2021). These things are the principles applied in the development of this application. Several studies that have been carried out in previous studies have also become the author's reference in conducting research. For example, research on the implementation of KAHOOT gamification. KAHOOT is an application that can help students during the learning process through individual or group games with different levels (Ismail, et al., 2018; Nikmah, 2020). Then research in the development of learning applications through gamification of AMIK PGRI Kebumen Quiz for students of the Information Management Study Department, which can motivate students to study for students of the study program (Sayekti, 2019). The implementation of gamification at iDu (iLearning Education) and iMe (iLearning Media) at Raharja School is a learning innovation to motivate students to learn (Rahardja, Aini, & Khoirunisa, 2019). The application of mobile learning for mathematics learning application based on the android mobile platform providing video material and evaluating the work of the questions. It can create a sensation of games enjoyed by 1st-grade elementary school students (Octafiani, Tejawati, & Pohny, 2017). Of course, these various studies were balanced with the content of teaching materials that were transformed into the concept of gamification. Yosi's research suggests that teaching materials are a primary need in the teaching and learning process through the Brog and Gall development model into seven stages, namely potentials and problems, data collection, product design, product validation, product revision, product testing, and product revisions (Wirawan & Yunian, 2018). Various previous studies have supported the author in developing interesting and interactive teaching materials through the concept of gamification. The concept of gamification that is built specifically for ASD students in certain subjects is a prototype for the object of the author's research.

Gamification is a basic concept given to three ASD students who are active in the Information Systems Department, at Universitas Komputer Indonesia. As a prototype, two courses, namely, the Algorithm and Basic Programming course and the Lab. Programming courses are packaged in gamification. The material presented in the games that students must complete is based on theoretical and practical video material. Then in the process, the game consists of seven levels which state the levels of learning that must be completed. Each level contains theoretical and practical material as well as evaluation through the form of questions that must be resolved until students successfully complete the mission in the game. The products are built on a desktop platform with a stand-alone installation which can be downloaded on the UNIKOM Learning Management System. The purpose of this study was to obtain an application in the gamification concept that could streamline learning courses for ASD students who needed repetition.

**METHOD**

This research began with data collection through the implementation of a group discussion forum with seven lecturers, three ASD students and their parents as well as a child psychology expert staff. The data was analyzed using the Strength, Weakness, Opportunity, and Threat (SWOT) model by mapping the various needs for the learning process of ASD students to identify internal and external environments (Benzaghta, Elwalda, & Mousa, 2021). Then do the design, development, and testing of the application. For design, is based on semester plan by consider on Algorithm and Basic Programming course and Lab. Programming course. The design focuses on how to conceptualise gamification, which includes creating storyboards, characters, game challenges, and interfaces. For development, make a prototype of a multimedia application with that gamification concept. Then testing is done by the lecturers who teach the courses, the ASD students, and their parents who can join and monitor their children’s learning using the black box method for functional testing and User Acceptance Testing (UAT) to ensure that the multimedia application satisfies the user’s needs (Otaduy & Diaz, 2017; Roman, 2018).

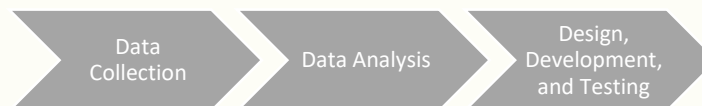


Figure 1. Research Method

**RESULTS AND DISCUSSIONS**

The research results were carried out through the application of research stages: data collection; data analysis; and design, development, and testing as in Figure 1.

**Data Collection and Data Analysis**

The data collection involved various stakeholders, namely lecturers, child psychologists, ASD students, and ASD parents, in a group discussion forum. The data obtained is focused and segmented from the technical side, which includes the process and support for learning needs, and non-technical, which includes support outside the learning process. This is analyzed using the SWOT model to get a description of the internal and external environment in the learning process of ASD students. Table 1 is a SWOT matrix for analyzing the learning process needs of ASD students.

Table 1. Internal & External Environmental for Development of Learning Process Application for ASD Students based on SWOT Analysis

<i>Strengths</i>		<i>Weakness</i>	
1.	Lecture infrastructure supported by the government and universities	1.	The lecture process in the classroom does not cover the needs of ASD students
2.	The availability of an LMS that can be accessed by lecturers and ASD students	2.	There is no standard for a lecturer who teaches courses

	<i>Strengths</i>	<i>Weakness</i>
	<p>3. Adequate internet network in the city of Bandung</p>	<p>to provide a certain assessment (evaluation)</p> <p>3. Limited development of multimedia material for all lecturers</p> <p>4. The Semester Learning Plan does not differentiate students with special needs from other students</p> <p>5. Lack of collaboration between parents and universities in providing support for ASD student</p> <p>6. Other student sentiments regarding "rejection" in interacting with ASD students</p>
<i>Opportunities</i>	<p>1. Packaging of various courses in multimedia content that can be understood by ASD students through the use of digital learning supported by various associations/institutions (S1, S2, S3 - O1, O3)</p> <p>2. Lecturer guidance to ASD students that can be done at any time using the available access to information technology (S1, S2, S3 - O2)</p>	<p>1. Provision of a Semester Learning Plan with a version of students with special needs (ASD) with a focus on technical, media, and evaluation of learning in various subjects (W1, W2, W3 - O1, O2)</p> <p>2. Expansion of teaching materials developed in the form of multimedia that can be built by each lecturer who holds the course (W1, W3, - O1)</p> <p>3. Development of media in monitoring the learning development of ASD students between parents of ASD students and subject lecturers (W5 - O1)</p> <p>4. Development of models or procedures for the involvement of ASD students in various university activities (W6 - O2)</p>
	<p>1. The importance of the availability of the multimedia division in transforming the material into multimedia content oriented towards ASD students</p> <p>2. The involvement of ASD students in several university activities</p> <p>3. Support from associations/institutions that focus on developing ASD students</p>	<p>1. Development of procedures and media in monitoring the learning development of ASD students between parents of ASD students and lecturers who teach subjects (W5 - T1, T2, T3)</p>
<i>Threats</i>	<p>1. Providing access to all stakeholders (lecturers, ASD students, and parents of ASD students) in the learning process for integrated ASD students using LMS (S1, S2, S3 - T1, T2, T3)</p>	
	<p>1. Monitoring, which is carried out by the lecturer, uniform all student needs without distinguishing certain needs</p> <p>2. Parents of students have not been thoroughly open to all lecturers in each subject holder regarding the development of ASD student</p> <p>3. ASD has not been able to be thoroughly monitored regarding developments in the implementation of studies</p>	

Based on the SWOT matrix, there is a need for ASD student-oriented learning as a priority: (1) Provision of a version of the Semester Learning Plan for students with special needs (ASD) by focusing on technical, media, and evaluation of learning in various subjects utilizing LMS, (2) Expansion teaching materials that are built in the form of multimedia that can be built by each lecturer who holds the course, (3) Development of procedures and media in monitoring the development of ASD student learning between parents of ASD students and lecturers who teach courses through the use of LMS, and (4) Development of models or procedures for ASD student involvement in various university activities.

### Design, Development, and Testing Gamification

Before designing and developing applications, we develop a Semester Learning Plan. The Semester Learning Plan that was built stated: (1) Identity of courses, (2) Mapping of learning outcomes of graduates and courses, (3) Reference, (4) Details of learning activities, and (5) Assessment and evaluation systems. Referring to the Semester Learning Plan, a multimedia application was built with the concept of gamification by providing teaching in video format (for theory and practicum) and implementing learning evaluations that were completed in a game mission. Development of prototype applications in Algorithm and Basic Programming course and Lab. Programming course. The choice of the two courses was due to the relationship and theoretical continuity, which was then practised in programming.

The development of teaching material in the Algorithm and Basic Programming course theoretically collaborated with the Lab. The programming course was practical programming. The seven teaching materials are presented in the form of seven learning modules (one material equals one module). The seven modules refer to the 'Study Materials' in Details of Learning Activities on Semester Learning Plan, consisting of (1) Introduction to Algorithms, (2) Data Types, (3) Input and Output in C Language, (4) Selection in Language C, (5) Loop in C, (6) Array in C, and (7) Struct. The seven modules have theoretical explanations in video format, a discussion of programming practicum in video format, and an evaluation in game format. The seven modules are packaged in an application with a .exe extension. Then the application is embedded in the university Learning Management System (LMS) so that it can be downloaded by every student, but especially for three ASD students. The application is packaged in a game format because the needs of ASD students in learning require repetition. In the game, repetition can be done so that the game becomes a concept that synergizes with the repetition they need.

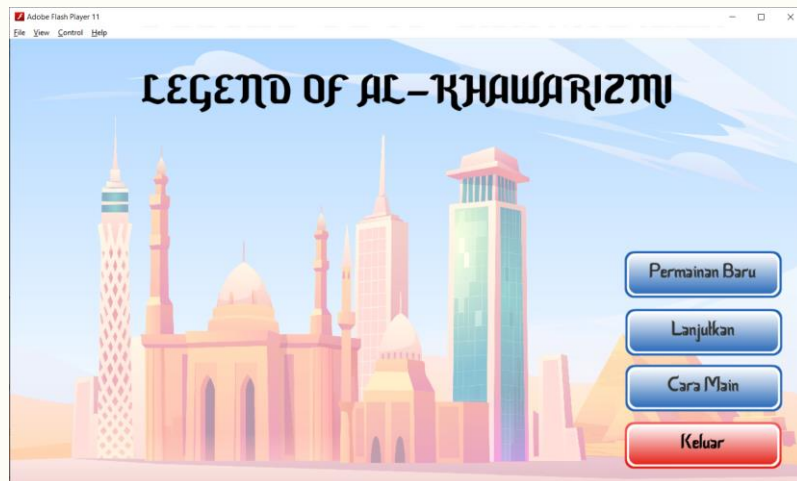


Figure 2. Main Menu

The theoretical explanation, discussion of the programming practicum, and evaluation of the game are given in each module. Each module has a theoretical explanation, programming explanation, and games, as shown in Figures 2 to 7. The Main menu is the main menu in accommodating all access to learning. There are videos of theoretical explanations and programming and games when accessing 'New Game' or 'Continue' as shown in Figure 2.



Figure 3 is the scene displayed after the user selects 'New Game.' The initial cutscene display is in the form of an animated video that tells the origin of the land of Al-Jabar, which was originally a land of seven wonders to a land of seven ignorance. The main mission of this game is to return the country of Al-Jabar to a land of seven wonders again. By completing all missions in each city (a total of seven cities). One city is a representation of one module, which means that the total of the modules taught is as many as seven "Study Materials" according to the Details of Learning Activities on Semester Learning Plan.

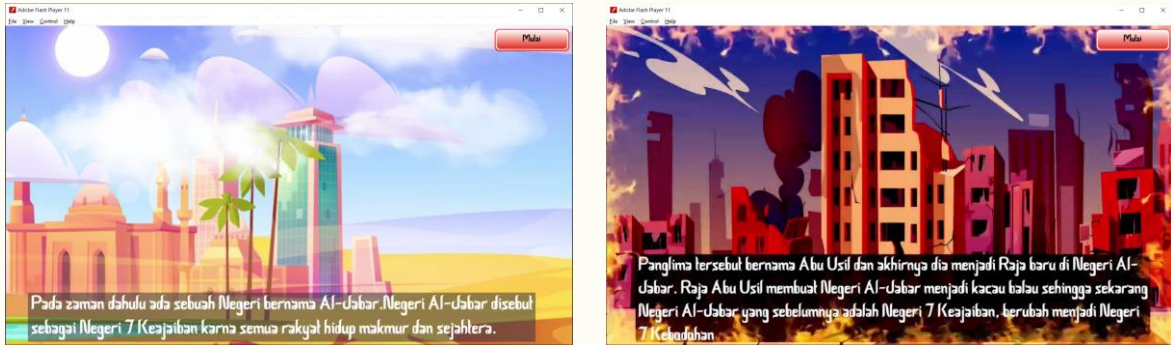


Figure 3. Early Cutscenes

Figure 4 shows the starting city (first) and the second city where the game mission starts with the next city to the seventh city. The player (named "Algo") must complete a mission in this city to go to the next city. Each city has three portals and four items (namely: (1) 'Potion' to restore HP; (2) 'Piptiptipi' to be used to override two wrong answers between A, B, C, and D; (3) 'Taluk' to be used to give up on a given question; and (4) 'Portal' to move to Scene Theory, Practicum, and Dungeon). Figure 4 shows the Town-01 and Town-02 scenes. This implies learning Module 1 and Module 2. Basically, there is Town-01 to Town-07, which states Module 1 to Module 7. Each Module will display a different scene plan depending on each module.

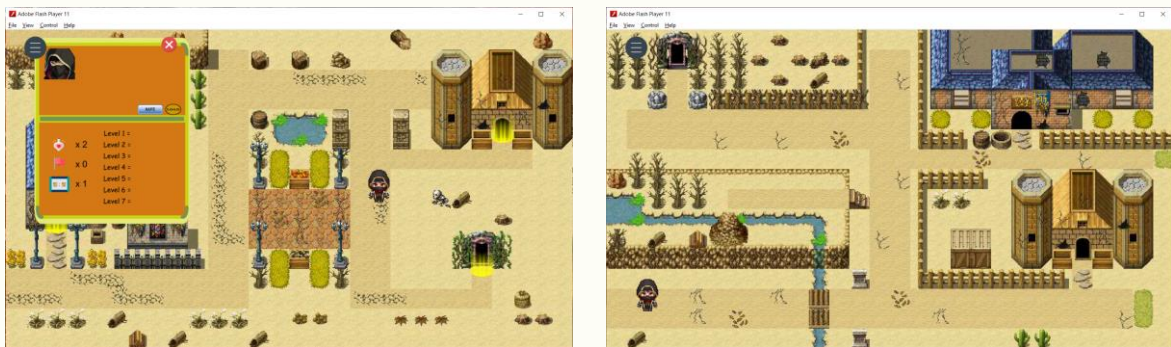


Figure 4. Town-01 and Town-02 Scenes

Figure 5 shows the video format that explains the theory. The video will appear when the user points the player icon into each portal. When the player enters it, a video will be displayed according to Figure 5, which contains an explanation of the introduction of the algorithm, the history of the algorithm, examples of the algorithm used, and the importance of learning algorithms.

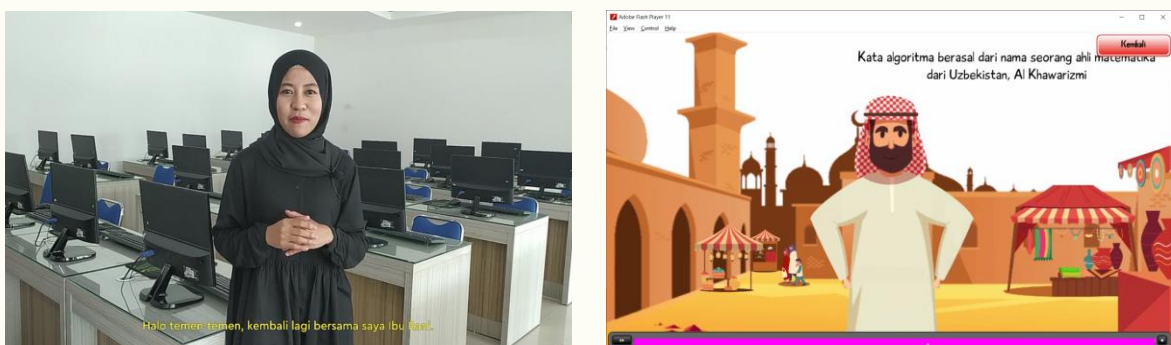


Figure 5. Town-01 Scene (Theory: Introduction to Algorithms)

Whereas Figure 6 states a video explaining the implementation of data types in C language and how to use them (practicum). This scene is obtained if the player enters another portal. Basically, all videos, both theoretical and practical, are equipped with animation and subtitles.



Figure 6. Town-02 Scene (Practicum: Selection in C Language)

Figure 7 shows the scene, which is the main requirement if you want to enter the next city. The Player (Algo) must complete a mission in the form of defeating small enemies and bosses. The way to defeat the enemy is to answer the questions correctly. In this scene, there are three small enemies and one 'boss.' Then the player (Algo) must be at this level 'boss' by answering questions from the 'boss.' Each question is represented by the HP 'boss,' which is three questions. The Player (Algo) can use items that have been previously collected. If the 'boss' HP runs out or all the questions are answered correctly, the player will head to Town-02. But if the player's HP runs out, the player will return to Town-01 and must repeat the mission from the beginning of the level. This is intended for users to learn again before finally ready to defeat this level boss.

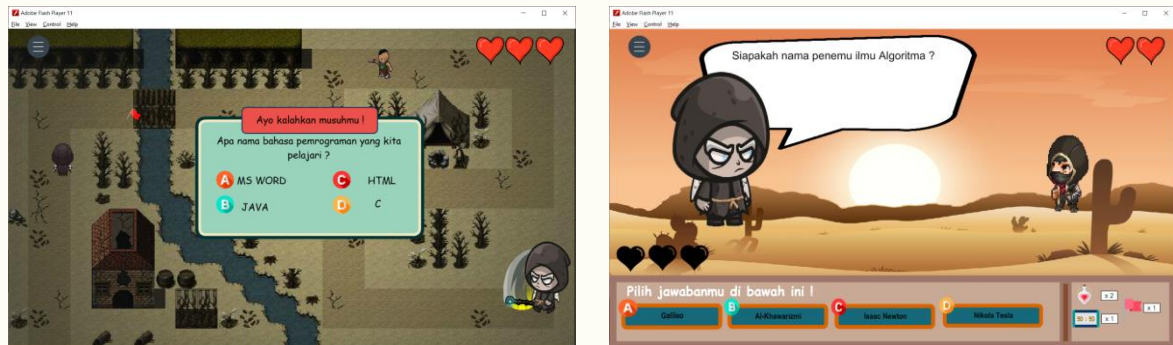


Figure 7. Dungeon Town-01 Scene

Testing is done using black box testing with a focus on functional testing conducted by two lecturers who teach the courses, ASD students, and their parents as shown in table 2. Blackbox testing is carried out by three types of users, namely students, parents of students, and lecturers to show the point of view of these users considering that functional multimedia applications can be used by various types of users. Tests are carried out on various computer devices with multiple specifications. The test results suggest that the overall functionality of multimedia applications is appropriate, with a 100% success rate. Based on UAT testing by ASD students, their parents, and lectures, this gamification of multimedia application has a high acceptance rate from ASD students 95.55%, their parents 91,11, and lecturers 86,67 as shown in table 3. This indicates that multimedia application is acceptable and can support learning for ASD students.

Table 2. Black box testing results

No.	Respondents	Acceptance Rate
1	Laptop Student A	100%
2	Laptop Student B	100%
3	Laptop Student C	100%

4	Laptop Parent's A	100%
5	Laptop Parent's B	100%
6	Laptop Parent's C	100%
7	Laptop Lecturer A	100%
8	Laptop Lecturer B	100%

Table 3. UAT Results for ASD Students, their parents, and lecturers

ASD Student		
No.	Respondents	Acceptance Rate
1	Student A	100%
2	Student B	93,33%
3	Student C	93,33%
	Means	95,55%
Student Parents		
No.	Respondents	Acceptance Rate
1	Student Parent's A	93,33%
2	Student Parent's B	93,33%
3	Student Parent's C	86,67%
	Means	91,11%
Lecturers		
No.	Respondents	Acceptance Rate
1	Lecturer A	93,33%
2	Lecturer B	80%
	Means	86,67%

This research emphasises how repetition packaged through multimedia applications can support the learning process for ASD students. Previous research through what was stated by Barghani (Barghani, 2020), Darman (Darman, 2023), and Goswami (Goswami, Arora, & Ranade, 2021) reaffirmed that this multimedia application can significantly serve as a means to improve the understanding of teaching materials. Then in line with Legaki (Legaki, Xi, Hamari, Karpouzis, & Assimakopoulos, 2020), Nikmah (Nikmah, 2020), Pradiante (Pradiante, 2022), and Simões-Silva (Simões-Silva, et al., 2022), this multimedia application is able to encourage ASD students to learn through gamification. While Kotob (Kotob & Ibrahim, 2019), Ocatafiani (Ocatafiani, Tejawati, & Pohny, 2017), Raed (Raed, 2018), and Ribeiro (Ribeiro, Silva, & Mussi, 2018) research reconfirms that this prototype can motivate ASD students. As a whole, this research confirms that multimedia applications with the concept of gamification are able to provide educational efficiency for ASD students with various benefits and impacts that can be felt for them.

## CONCLUSIONS

The development of teaching material applications is applied to the Algorithm and Basic Programming course and Lab. Programming course as a prototype. The application is specifically for ASD students. The multimedia application is packaged in a gamification concept to provide an interesting and interactive audiovisual through the provision of theoretical and practical material through video and evaluation through the completion of a mission in a game. Based on testing, ASD students, their parents, and lecturers can accept these multimedia applications as a support tool for ASD students' lectures with the goal is to efficient delivery of learning material in the learning process for ASD students with the impact of enhancing the learning process for them. This research has limitations in determining the teaching material considering that the main basis is from the Semester Learning Plan which tends to change every year due to curriculum changes. Then system conversion is needed so that its use can be accessed on mobile devices, not only using laptops or desktops, and this one can be a reference in the development of further research.



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