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Elimination of Waste in the Development of Learning Media for Deaf Students Using a Lean Software Development Approach

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ABSTRACT

Deafness is a condition where a student cannot hear various sounds optimally. So in the learning process, we need media that prioritizes visuals to make it easier for deaf students to understand the material presented by the teacher. Gamification is one of the most effective learning media because it can present material packaged in the form of game software. The aim of the research is to assist developers in developing gamification by eliminating waste using a lean software development approach. This research method uses the lean assessment matrix method by making process flow diagrams and lean assessment matrices to identify the presence of critical waste. The results showed that the development of deaf students' learning methods used the Lean Software development approach: the number of motions in one game, the game entry process was quite long, and the Latin font was not installed in the application. By eliminating these three wastes, other wastes will be indirectly eliminated because there is a link between the wastes. After the Lean Assessment Matrix process was completed, several solutions were obtained to eliminate this critical waste: making a Future Process Model carefully before giving it to the Developer and making a careful gamification development schedule. By implementing the two Garbage Elimination Alternatives, gamification development can run effectively and efficiently.

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1. INTRODUCTION

Special Schools (SLB) are places to improve abilities or proper education given to persons with disabilities, including those who are deaf or children with hearing impairments. Deaf students are defined as students with hearing loss, causing them to be unable to grasp material through their hearing. The

school accommodates deaf students in classrooms suitable for their level of hearing loss. Those who are hard of hearing are placed into one of several categories based on their educational needs, including those with Slight Losses, Mild Losses, Severe Losses, and Profound Losses. Deaf kids receive services through Special Schools (SLB) since they fall under this category. Due to their impairments, Deaf students have more trouble retaining information than their hearing peers do when learning new material (Dandashi et al., 2015). Students who are deaf or hard of hearing are among the diverse population of children with special needs. In light of these challenges, educational materials for people who are deaf or hard of hearing should emphasise visual components (Witaharahap & Surya, 2017).

Gamification emerged along with the development of science and technology (IPTEK). The development of science and technology in the learning process will impact the development of new learning resources and learning media. A computer is a tool that has begun to be used as a tool for developing computer-based learning media (information and communication technology/ICT). ICT is now an important tool influencing the country's education quality (Brown et al., 2009). Gamification can help students motivate and make their learning process more effective by implementing digital media learning for their students. Developing a gamification is the same as developing software in general, which has an initial design, visualization, materials to be inserted, and prototypes, to become a complete gamification. So in this research, the development of gamification for deaf students will be carried out using a Lean Software Development approach.

Lean Software Development is a strategy or mindset to reduce waste and save work time in software development so as to provide significant added value to the software developed (Poppendieck, 2003). If in Lean Manufacturing, there are 7 wastes consisting of motion, waiting/delay, overprocessing, overproduction, inventory, transportation, and defects (Liker, 2004), then in Lean Software Development, these seven wastes are known as Partially Done Work, Extra Processes, Extra Features, Task Switching, Waiting, Motion, and Defects (Poppendieck, 2003). According to Rawabdeh (2005), it proves that waste within the company can be interrelated and the waste that has the most influence on other wastes is called critical waste. This theory, of course, also applies to waste in software development, according to Poppendieck (2003). The philosophy of Lean is a systematic approach in identifying and eliminating waste (non-value-added activities) which can be achieved by making continuous improvements such as flowing products from raw materials, WIP to finished products using a pull system from customers for the purpose of customer satisfaction (Vincent Gaspersz, 2007)

The five key rules for putting the lean concept into practice (Rother & Shook, 2003) are: First, define the value. From the consumer's point of view, it means something that adds worth to the product or service. Second, make a list of the whole value chain: Find the steps that are done, starting with the design of the product, ordering the materials needed for production, and entering the value stream. This will help you find the activities that don't add value and cause waste. Flow is the third. It adds value to tasks that are done without redo, backflow, waiting tasks, or production waste. I pull the fourth. It knows what needs to be done to make what the customer wants. The last one is just right. It tries to get rid of waste by constantly getting better and getting closer to perfection.

Lean is a method of production that was popularised by Toyota. The goal of the Lean concept is to maximise value for customers by reducing inefficiencies in the use of resources including time, money, space, and labour (Pascal, 2015). Lean software development is often commonly referred to by its acronym, "Scrum." Poppendieck (2003) defines "Lean Software Development" as "a strategy or mindset for minimising waste while maximising efficiency in software development in order to deliver the greatest possible value to the customer." Seeing Waste and Value Stream Mapping are two of the many tools used in Lean Software Development. The House of Risk thinking logic, as applied to Lean Software Development, yields the Lean Assessment Matrix, a tool for locating waste and exploring causal connections between various types of waste. Both Lean Matrix 1 and Lean Matrix 2 make up the Lean Assessment Matrix (Karningsih et al., 2019). Non-value-added activities (NVA) in the form of crucial waste can be identified using the Lean Matrix 1 (Karningsih et al., 2019). Using this matrix, we can rank the waste from most crucial to least influential based on its proximity to the cause of the

problem. Lean Matrix 1 can be compiled using the methods outlined in (Karningsih et al., 2019). The results of Lean Matrix 1's computations are used to rank potential enhancements or fixes for the most pressing waste in Lean Matrix 2. Prepare a number of potential enhancements for important waste, and then assemble Lean Matrix 2 according to its directions (Karningsih et al., 2019).

Waste is described as everything that does not contribute to the success of a business and, as a result, can raise expenses and cut into profits (Liker, 2004). Lean manufacturing and Lean software development approach waste in different ways. In both cases, the focus is on eliminating waste, but in Lean Manufacturing, it is on the factory floor and in Lean Software Development, it is in the code. There is a connection between these wastes and how they influence other waste streams (Rawabdeh, 2005).

The research conducted by Nurrita (2018) found that the results of the product development had been validated by material experts with an analysis of the acquisition of 87.27%. Meanwhile, the assessment of media analysis experts obtained 89.23%. Based on the results of the second analysis, the validation of media experts and digital flashcard material experts can be categorized as very good. In line with the research conducted by Witaharahap (2017), it was concluded that media perception, feelings during and after media use, and the average attention span were very good. Based on the results obtained during the experiment, the developed media proved to have a positive impact on deaf children. Therefore, in this study, the authors will identify critical waste in Gamification for deaf children in order to design solutions to reduce the presence of this waste. The method used includes the Lean Assessment Matrix, developed by Rawabdeh (2011) and modified by Karningsih et al. (2019).

2. METHODS

The subjects used in this study were SLB students in Surakarta and Sukoharjo. This research method uses the lean assessment matrix method by making process flow diagrams and lean assessment matrices to identify the presence of critical waste. These differences can be seen in the following table.

Table 1. Waste in Lean Manufacturing and Lean Software Development

Lean Manufacturing	Lean Software Development
Inventory	Partially Done Work
Extra Processing	Extra Processes
Overproduction	Extra Features
Transportation	Task Switching
Waiting	Waiting
Motion	Motion
Defects	Defects

(Poppendieck, 2003).

Table 1 analysis related to waste in lean manufacturing and software development in this study is meaningful in 3 categories, namely the man category, which is the root cause of the problem of waste, namely inventory, extra processing, partly completed workers and extra processes. In the machine category, the causes of overprocessing waste problems are overproduction of transport, waiting, extra features and producing tasks. The material category is the category that is the cause of the root cause of the wastage defect, namely waiting for movement and recording.

3. FINDINGS AND DISCUSSION

From the identification that has been written, the sequence of research results is:

3.1. Identifying Waste in Software Development

Table 2. Waste in Gamification For Hear Impaired Student

Waste Type	Code	Existing Condition
Defect	W1	There is a defect in the form of a product font character that is not a Latin letter.
Extra Features	W2	There are music settings that are not really needed
Waiting	W3	When logging into the game takes a long time
Waiting	W4	Repetition of animation is quite a time-consuming
Motion	W5	Too much motion in the word game
Extra Processing	W6	There are many revisions related to the game
Extra Processing	W7	Too many dialogues, so it takes up a lot of processing

The table above is an identification obtained related to waste and development in software. From the analysis above, it can be concluded that the types of waste in gamification for deaf students are divided into 7, including notes, extra features, waiting (waiting in the game takes quite a long time and the duration of the animation repetition), movement, and extra processing. Each type of waste listed has a different excitation condition. An example is the type of waste records that provide an explanation in the existing condition that there are notes in the form of product font characters that are not Latin letters. As well as other types of waste adapted to existing conditions.

After identifying the waste contained in the gamification design for deaf students, then a search for the root cause of waste is then carried out so that the root cause of the waste is known.

Table 2. Root Source of Waste in Gamification For Hear Impaired Student

Root Source of Waste	Description
S1	Less regular gamification development scheduling
S2	Early gamification design that is not mature
S3	Developers are not careful in making the back end
S4	There are obstacles in the game development process
S5	The material presented in the game is uncertain
S6	Lack of knowledge of game variations

From the table above it can be concluded that the roots of the waste source are divided into 6 categories with each cause. The relationship between each waste root is very complex, which can be seen directly or indirectly so that an assessment framework is created at the root level of the waste source. For example, an irregular development schedule will result in an immature initial gamification design. The 6th relationship can be seen in the table above.

3.2. Preparation of Lean Matrix 1

From the results of the identification of waste and the root source of waste, Lean Matrix 1 is then compiled which aims to find critical waste so that it can be determined which waste most needs to be removed so that other wastes can also disappear. By following the steps for making a lean matrix (Karningsih et al., 2019), lean matrix 1 is obtained as follows.

Waste Type	Waste	S1	S2	S3	S4	S5	S6	Waste Type Weight (%)	Severity level of Waste	Aggregate Waste Number	Waste Rank
Defect	W1		3				1	22.42	7	5650.91	3
Extra Features	W2	1			3			16.36	2	687.27	6
Waiting	W3	9		9	9	3	3	20.00	2	8280.00	2
	W4		1					14.45	10	1445.43	5
Motion	W5			9				100.00	4	36000.00	1
Extra Processing	W6	1	9	1	3			0.00	6	0.00	7
	W7		1		1			15.93	7	1784.07	4
Occurance level of Root Source of Waste j		3	10	10	6	4	5				
Aggregate Cause value		78	920	600	294	24	65				

Figure 1. Lean Matrix 1 for Gamification

The lean matrix reveals that the number of moves in a single game, the length of the game login process, and the absence of a Latin font are the three most problematic areas. These three types of garbage should be dealt with as quickly as possible. To ensure a smooth and efficient development process for gamification applications that serve the original goal of facilitating information access for deaf students. In addition, an enhancement analysis is performed based on the three essential wastes to reduce or get rid of them.

Table 3. Root Source of Waste in Gamification For Hear Impaired Student

WE1	Repair Alternative
WEA1	Make the Future Process Model carefully before giving it to the Developer
WEA2	Carefully schedule gamification development.
WEA3	Conduct a literature and curriculum review for the right game selection.
WEA4	Perform data collection as completely as possible
WEA5	Doing Voice of Customer

Five alternative improvements will then be input in Lean Matrix 2. Lean matrix 2 is formed according to the steps according to Karningsih et al. (2019)

Waste Type	Root Source	Waste Elimination Action					Aggregate Cause i
		WEA1	WEA2	WEA3	WEA4	WEA5	
Defect, Waiting and Motion	S1					9	78
	S2	9	9				600
	S3				3	3	294
	S4			9	9		24
	S5			9			65
Total Effectiveness of Waste Elimination Action m (TEm)		5400	5400	801	1098	1584	
Degree of difficulty performing action m (Dm)		3	5	4	4	5	
Effectiveness in difficulty ration (ETDm)		1800	1080	200.25	274.5	316.8	
Rank of action priority		1	2	5	4	3	

Figure 2. Lean Matrix 2 for Gamification

Based on the analysis and calculations through Lean Matrix 2, it can be concluded that the best alternative is WEA 1, namely by carefully making the Future Process Model before being given to the Developer. The next improvement alternative is in WEA 2, namely by carefully making a gamification development schedule.

3.3 Discussion

Designing an application or game is the same as designing a business process for an agency, if the game is intended for a subject, especially for deaf students, it is necessary to design the supporting elements first. According to Mustikasari (2022), the sequence of designing learning media starts from analyzing the needs of the characteristics, formulating instructional goals, formulating detailed material items that support the achievement of goals, developing success measuring tools, and writing media scripts. Based on the sequence, it can be concluded that a coherent sequence is needed to write a media script in designing a game. Media script writing can be done using a future process model. Future Process Model, or Business Process Modeling (BPM),s a technique used to analyze and model business processes (Sari & Asniar, 2015). This model can be shown in the form of a flow chart. The following is a business portrait of gamification designed for deaf students according to the required curriculum.

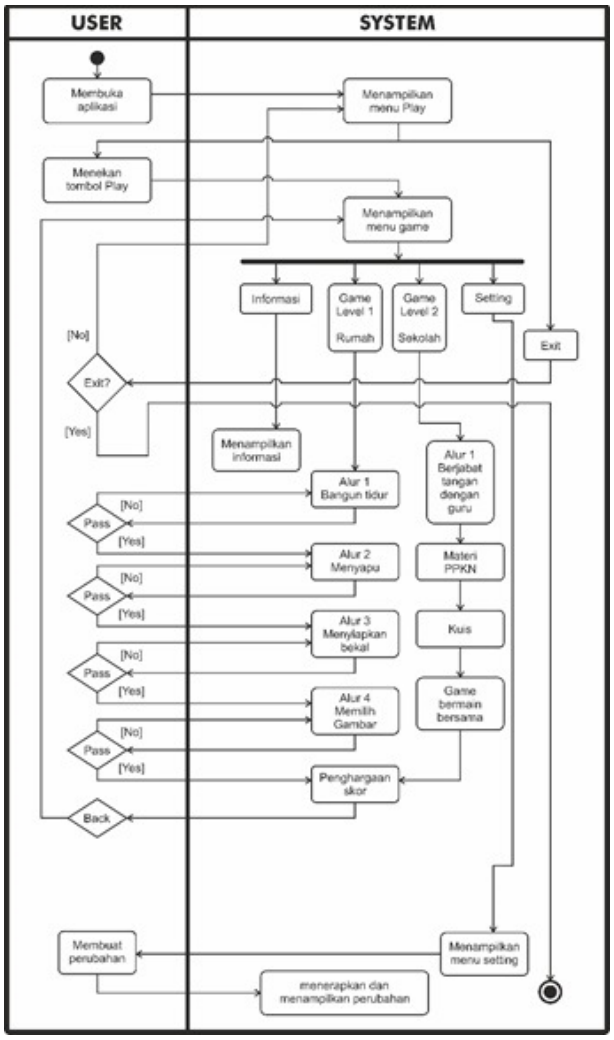

Fig 3. Example of Flowchart Gamification for Hearing Impaired Student

In addition to designing flow charts, and modelling business processes on gamification for deaf students, proper visualization is needed. In visualizing gamification, you can rely on the catalysis framework. The catalysis framework contains strategies for building and analyzing gamification in which there are eight cores that can bring users to be more motivated to play games (Landsell & Hagglund, 2016). Some game displays that need to be visualized with the catalysis framework approach include Main View, Achievement View, and Main Game View (Mustikasari, Yusuf, & Rejekiningsih, 2022). After creating a future or business process model, the next step in minimizing the second waste is to make a careful gamification development schedule. As explained by Nurrita (Nurrita, 2018) if there are several important steps before making a flow chart, then the flow chart will become an important foundation for engineers in making gamification applications. So that each stage can be passed with certainty, a good schedule can be made before conducting research. One of the tools for making a good research schedule is to make a Gantt chart.

Gantt Chart is a tool used to describe a simple project or a large project. Gantchart is widely known as a fundamental tool that is easy to apply by project managers to monitor the project progress based on the start and completion time of tasks and sub-tasks of the project (Anom, 2015). When linked in this study, the tasks and sub-tasks included in the Gantt chart can include the stages in designing gamification learning media, namely analyzing the needs of the characteristics, formulating instructional objectives, formulating detailed material items that support the achievement of goals, developing tools measuring success, and writing media scripts. Each stage so that it can be completed completely can be described in several sub-tasks or stages, so that a complete

and detailed Gantt chart can be compiled so that the course of gamification development does not experience shortages and is effective in processing time. The following is an example of a Gantt chart that can be used in developing gamification learning media.

Table 5. Example of Gantt Chart for Developing Gamification

Task Name	7 March 2022							14 March 2022							21 March 2022						
	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
Analyzing Needs and Characteristics																					
Determine the object of research (School)																					
Conducting interviews on the object of research																					
Request a learning curriculum on the object																					
Formulating Instructional Goals																					
Read and understand the curriculum of the object																					
Determining learning objectives																					
Determine targets to be achieved according to the curriculum																					
Formulating Material Items that Support Goals																					
Summarizing the curriculum in the form of material items																					
Make the initial game design according to the material items																					
Developing Success Measuring Tools																					
Create a material expert validation questionnaire																					
Create a media expert validation questionnaire																					
Make a teacher assessment questionnaire																					
Make pretest and posttest questions																					
Writing Media Scripts																					
Designing Flow Charts																					
Designing a Storyboard																					
Perform validation																					
Doing development with Engineer																					

From the Gantt Chart, it can be used as a schedule guide and the tasks that researchers must do in carrying out gamification development, so that researchers can better prepare carefully for everything that will be done because it has been scheduled. In carrying out the Gantt chart, researchers must be committed to running so that the research process does not experience obstacles that lead to waste in the gamification that is compiled later.

4. CONCLUSION

Lean Software Development is a method or frame of mind that aims to improve the quality of software by cutting down on unnecessary steps and economising on development time. To become gamified with high added value and save time in the process, a Lean Software Development method is required because gamification is the proper learning media for deaf students. Using the Lean Assessment Matrix, we identified numerous important wastes in the gamification of prior researchers, including the number of motions in a single game, the length of the game entry process, and the absence of a Latin font in the application. According to the findings of the available study, if these three pollutants are removed, other wastes will also be removed because of the connection between them. When these three wastes are gone, more waste will go away as a result of their domino effect. Several methods are identified for eradicating this key waste after the Lean Assessment Matrix approach, such as thoroughly crafting the Future approach Model before handing it off to the Developer and meticulously planning out the gamification of the development process. The development of gamification can proceed smoothly and quickly, provided the two Waste Elimination Alternatives are put into place.

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REFERENCES

Anom, K. (2015, May). *Gantt Chart & Diagram PERT*. Retrieved from http://komang_anom.staff.gunadarma.ac.id/Downloads/files/53732/Gantt+Chart+%26+Pert.pdf

Brown, T., McCormac, M., & Zimmermann, R. (2009). An Analysis of the Research and Impact of ICT in Education in Developing Country Contexts. *Journal of Education for International Development, 4*(2), 1-12.

Dandashi, A., Karkar, A., Aljaam, J. M., & El Seoud, S. A. (2015). Children with Hearing Impairments. *International Conference on Interactive Collaborative Learning (ICL2015).* Florence, Italy: World Engineering Education Forum.

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in Education. *Educational & Technology & Society, 18*(3), 75-88.

Juherna, E., Purwanti, E., Melawati, M., & Utami, Y. S. (2020). Implementasi Pendidikan Karakter Pada Disabilitas Anak Tunarungu. *E-Journal Hamzanwadi*, 12-19.

Karningsih, P. D., Pangesti, A. T., & Suef, M. (2019). Lean Assessment Matrix : A Proposed Supporting Tool for Lean Manufacturing Implementation. *IOP Conference Series: Materials Science and Engineering.* doi:10.1088/1757-899X/598/1/012082

Landsell, J., & Hagglund, E. (2016). *Towards a Gamification Framework : Limitations and opportunities when gamifying business processes.*

Liker, J. K. (2004). *The Toyota Way : 14 Management Principles from the World's Greatest Manufacturer.* New York, United States: McGraw-Hill.

Mustikasari, A. A., Yusuf, M., & Rejekiningsih, T. (2022). Storyboard Visualization for Gamification Design for Deaf Children's Education Using Octalysis Approach. Malang: AIBPM Publisher.

Nurrita. (2018). Pengembangan Media Pembelajaran Untuk Meningkatkan Hasil Belajar Siswa. *MISYKAT : Jurnal Ilmu-ilmu Al-Quran, Hadist, Syari'ah dan Tarbiah, 3*(1), 171.

Pascal, D. (2015). *Lean Production Simplified 3th Edition* (Vol. 3). London: CRC Press.

Poppendieck, M. (2003). *Lean Software Development : An Agile Toolkit* (1 ed.). Canada: Addison Wesley.

Pujawan, N., & Geraldin, L. (2009). House of risk : A model for proactive supply chain risk management. *Business Process Management Journal*, 953-966. doi:10.1108/14637150911003801

Rawabdeh, I. (2005). A model for the assessment of waste in job shop environments. *International Journal of Operations & Production Management, 25*, 800-822. doi:10.1108/01443570510608619

Rawabdeh, I. (2011). Waste Elimination Using Quality Function Deployment. *International Journal Services and Operations Management, 10*(2), 216-238.

Sari, S. K., & Asniar. (2015). Analisis Dan Pemodelan Proses Bisnis Prosedur Pelaksanaan Proyek Akhir Sebagai Alat Bantu Identifikasi Kebutuhan Sistem. *Jurnal Infotel, 7*(2), 143-153.

Wignjosoebroto, S. (1995). *Ergonomi Studi Gerak dan Waktu : Teknik Analisis untuk Peningkatan Produktivitas Kerja.* Surabaya: Prima Printing.

Witaharahap, L., & Surya, E. (2017). Development of Learning Media in Mathematics for Students with Special International Journal of Sciences. *International Journal of Sciences : Basic Applied Research (IJSBAR), 33*(3), 1-12.