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Development of Game-based Learning to Improve Understanding of Energy Source Material for Deaf Students

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Abstract

This research aims to develop game-based learning to improve deaf students' understanding of energy source material. The research method used in this study is research and development (RnD) with the ADDIE model to obtain comprehensive information in analyzing the learning barriers experienced by deaf students as the basis for developing game-based learning media. The subjects in this study were deaf students in grade VII who experienced learning barriers in the energy source material. The result of this research is game-based learning media on energy source material for deaf students in seventh grade. The content and material of energy sources contained in the game-based learning media have been adjusted to the learning needs and characteristics of deaf students. Game-based learning (GBL) learning media has proven effective for deaf students, with validation results from two material experts reaching 97.5% and media validation of 94%. The trial results found that GBL was able to increase deaf students' understanding of energy source material by 40%. The results showed that this game-based learning media is effective in improving the learning needs of deaf students on energy source material. In addition to being useful for deaf students, this educational game-based learning media is also expected to be used for other students who are learning science on energy source material.

Keywords: *Deaf student, Energy sources, Game-based learning, Learning media*

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INTRODUCTION

Life today is always influenced by the advancement of science and technology that continues to develop (Novi Yona Sidratul Munti & Dwi Asril Syaifuddin, 2020). The development of science and technology is very useful in modern life and cannot be avoided (Mulyani & Haliza, 2021). One of the impacts is in the field of learning media available outside of school time or the school environment (Anwar et al., 2020). The current digital era proves that the use of technology as a learning medium is very effective (Hafeez., 2021). The use of Technology in learning media provides opportunities for greater flexibility, interactivity, and accessibility, thus enabling more engaging and effective teaching and learning. Learning media can be used to create interesting teaching and transfer messages and information used in the classroom (Zahwa et al., 2022). Learning media should be made as good as possible to meet the different learning needs of students, because the success of the learning process is very important (Sungkono et al., 2022). One of the technology-based learning media development is through game-based learning (GBL).

Game-based learning is a game that is intentionally made for educational purposes as a support for learning media, because it is considered more interesting than the conventional teaching and learning process. Game-based learning is proven to improve students' achievement and support the education process. This is related to the design used in educational games, which consists of animation, appropriate color selection and attractive illustrations (objects) at each stage of learning or each topic in learning which is then applied to educational games (education game) (Dewi & Listiowarni, 2019). Digital GBL can have a positive impact on students' academic knowledge (Zou et al., 2021). Digital-based GBL learning media can make it easier for students to learn

anywhere and anytime (Gao et al., 2020). Ishak et al. (2021) revealed that students have a positive attitude towards GBL learning in mobile devices.

Currently, the role of learning media is very urgent, important in increasing the effectiveness of learning. The teaching and learning process in schools always has a goal to achieve certain expectations. To achieve certain expectations, the teaching and learning process needs to be meaningful for students. learning media is everything that is used as an intermediary or connector from the information provider, namely the teacher to the recipient of information or students which aims to stimulate students to be motivated and able to follow the learning process in a complete and meaningful way. Media is essentially one of the components of the learning system. As a component, the media should be an integral part and must be in accordance with the learning process as a whole, so the development of learning media is very beneficial for teachers, teachers can be effective and efficient in presenting subject matter if they can utilize the media properly and appropriately (Firmadani, 2020; Novitasari et al., 2023). The development of GBL is an effort to keep up with science and technology in the learning process, in its development GBL needs to be adjusted to the characteristics of students so that it is appropriate.

The characteristics of deaf students in the learning process need to be considered in designing learning media, including: deaf students are human eyes; difficulty in understanding an abstract concept; obstacles in understanding and receiving verbal and abstract information (Maryanti et al., 2020; Septiani & Nursaniah, 2023; Rizqita et al., 2024).Based on their characteristics, deaf students need development in an effective learning process (Csizér & Kontra, 2020) by paying attention to visualization, language style, and understanding abstract concepts so that the learning process is intact and meaningful, especially in natural science material. Science is one of the subjects that need to be mastered by deaf students, with science learning students in understanding, researching and analyzing nature, one of which is in the material of energy sources. Understanding energy source material is important in understanding how energy is used and how to save and optimize energy use.

Energy sources are everything that exists around the environment and is capable of producing energy (Octaviani et al., 2022). Energy sources need to be utilized properly and correctly because they will have an impact on human life (Bety et al., 2022). As an energy source that is around the environment, it is important as a human being to realize the existence of energy in daily life. Energy sources are divided into two types, namely natural and artificial energy sources. Natural energy sources are often referred to as natural resources which are divided into renewable and non-renewable natural resources (Bety et al., 2022; Fahmi Saifudin & Wedi, 2020). Renewable energy sources are a type of energy that comes from nature. Renewable energy sources are energy sources whose formation process occurs periodically so that the supply never runs out, for example solar energy, wind, water, buni heat, and others (Fitriani et al., 2024). Meanwhile, non-renewable resources such as petroleum and coal (Siregar, 2020). For deaf students, source learning material is limited to renewable natural resources (sun, water, and wind). Learning renewable energy sources needs to be learned for students because it will be the first step to provide knowledge to students for future energy management (Gumelar et al., 2019).

The development of game-based learning media has now been widely developed, including research conducted by Juhanaini et al. (2024) showing that GBL media is effective for improving the understanding of children with mathematics learning barriers (grade 5 elementary school students) on standard unit material. Research conducted by Maryanti et al. (2024) shows that technology-based learning media innovations also need to be provided for students with special needs, learning media need to be tailored to each student's needs. Novitasari et al. (2023) in their research developed a learning media for learning to read vocabulary for students with motor barriers, in its development the learning content is adjusted based on the results of the analysis of student learning needs. Juhanaini et al. (2025) conducted further research on the development of GBL media on arithmetic material, it was found that the GBL media development process began with an assessment process to reveal students' learning needs comprehensively. The results of research by Hanis et al. (2021) found that GBL needs to be developed by paying attention to aspects of curriculum, language, visual, and ease of access to be used as learning media. The results of previous studies have several similarities including the development of GBL based on the results of the assessment of student learning

needs, but until now there has been no research for the development of GBL to improve understanding of energy source material for deaf students to accommodate student learning needs and teacher teaching needs. This research aims to help students understand the concept of energy sources designed based on the learning needs of deaf students. The development of this learning media is expected to be effective for deaf students in understanding the concept of energy source material.

METHOD

This research is a type of research and development. The product was developed in the form of GBL learning media to improve the understanding of deaf students in grade VII on energy source material. The subjects in this study include validators, class teachers, and seventh-grade deaf students at special schools in Bandung city. The method used in this research is RnD with the ADDIE development model which consists of five stages, including analysis, design, development, implementation, and evaluation.

Analysis, conduct a preliminary study or literature study to review, investigate, and gather information. This stage includes various activities such as needs analysis, literature review, initial classroom observations, identification of problems encountered in the knowledge of deaf children related to energy source material and collecting data about learning conducted by teachers.

Desain, at this stage the product development design is planned. Important aspects of the planning include what the product is about, what its purpose and benefits are, who the users of the product are and where they are located and why the product is considered important.

Development, of an initial product form that is temporary (hypothetical). The products made are as complete and good as possible, such as the completeness of the media components, instructions for use, validation, product revision, revised learning media, and assessment systems.

Implementation, the limited implementation stage of the product was conducted in the field involving seventh grade students at one of the special school in Bandung City consisting of 7 deaf students. During the trial, observations were made of the subject and teacher activities in implementing the product.

Evaluation, the evaluation stage is carried out based on the implementation result. This stage is carried out to provide value to the development of GBL media.

The data collection technique used in this study uses expert validation sheets (material validation and media validation) and the ability to understand energy source material test sheets in various forms of questions that have met valid and reliable criteria. Data processing and analysis techniques are carried out through several stages, including: media feasibility analysis, material feasibility analysis using a Likert scale with points 1 (cannot be used) and 2 (can be used with revision), 3 (can be used without revision), as well as improving the ability to understand energy source material for seventh-grade deaf students at special schools in Bandung city.

RESULT AND DISSCUSION

Analysis

Based on the results of observations made at two schools in Bandung City, science learning was found that the special school used visual learning media, namely with pictures of energy sources but the learning process was one-way (through the lecture method). Based on the results of interviews and observations with teachers and students, it was found that there were difficulties faced by students, namely students' understanding of energy sources whose utilization was abstract if learning was carried out classically in a classroom setting with the lecture method. Deaf students need innovative media that is not only focused on images but how the media can reveal facts to understand the material of energy sources that are packaged interestingly. In line with these needs (Rahmi, 2020) suggests that the media designed also needs to help deaf students to concretize abstract material. The teacher also said that sometimes he uses video learning media but the learning videos are not designed by the teacher but videos from YouTube social media.

The results of the analysis found that there is a need for a teaching aid that can accommodate the characteristics and learning needs of deaf students to improve students understanding ability. This development has novelty because until now there has been no research on the development of game-based learning to improve understanding of energy source material for deaf students. Game-based learning is a game (game) that is deliberately made for educational purposes as a support for learning media, because it is considered more interesting than the

conventional teaching and learning process. Game-based learning is proven to improve students' achievement and support the education process. This is related to the design used in educational games, which consists of animation, appropriate color selection and attractive illustrations (objects) at each stage of learning or each topic in learning which is then applied to educational games (education game) (Dewi & Listiowarni, 2019).

Design

At this stage, product development design planning is carried out. At this stage, researchers designed the material, content, and gameplay, for the components designed including material content consisting of:

a. The material content on GBL consists of large content, namely energy source material. Energy sources are everything that exists around the environment and is capable of producing energy (Octaviani et al., 2022). Energy sources need to be utilized properly and correctly because they will have an impact on human life (Bety et al., 2022). Figure 1. explains in GBL media, energy source material consists of three levels, namely the basic concepts of energy sources (level 1), types of energy sources (level 2: Sun, Water, and Wind), and utilization of energy sources (level 3).

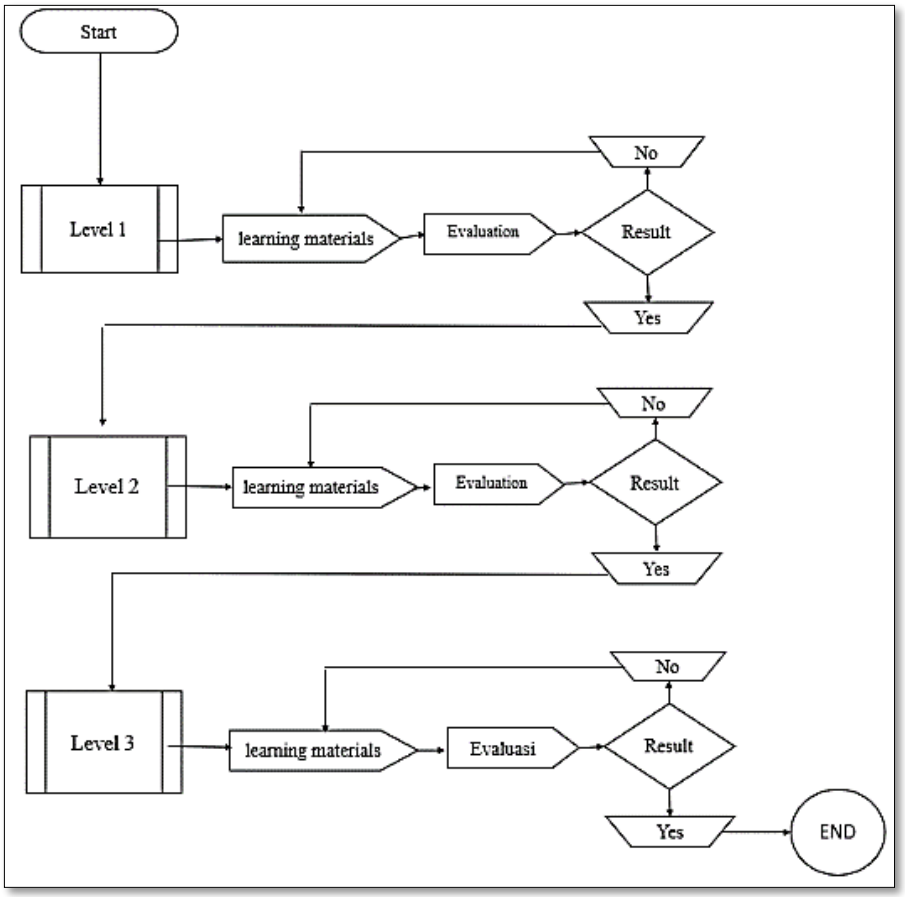

Figure 1. Game flow in game-based learning

b. The energy source material is prepared to improve deaf students' understanding of energy source material with details in Figure 1. basic concepts of energy

c. The rules in this GBL require students to complete the learning material and evaluation in level 1 (basic concepts of energy sources) to access level 2. If students have not completed the evaluation at level 1 with a minimum criterion of 80, students will repeat the material and evaluation again at level 1, this rule applies to access levels 2 and 3. Prerequisite learning ensures that students have the necessary knowledge base before proceeding to more complex material (Zakiyah & Ulfia, 2024). Energy source learning needs to be learned for students

because it will be the first step to providing knowledge to students for future energy management (Gumelar et al., 2019).

Development

Product development was conducted with partners to create game-based learning media. The preparation of content, materials, and evaluation was carried out by researchers without involving partners. After the GBL media was completed, validation was carried out to ensure the validity of the GBL media that had been developed. Validators consisted of 2 material experts and 1 media expert. Suggestions and assessments from validators are used as a basis for conducting validation improvements to the learning media. The following are the learning validation from experts along with product revisions which is done:

Material Expert Validation

Material experts aim to provide validation of energy source material on GBL learning media. content validity is validity that will check the match between test items made with indicators, material or learning objectives that have been set. In this study then, this validity checks the match between the test items and the aspects being assessed. Table 1 shows the validation results from material experts.

Table 1. Material validation result

Number	Validator Initials	Content	Presentation of material	Language	Result
1.	D.R	100	98	98	98%
2.	R.R	100	98	94	97%
		Total			**97.5%**

The average score of validator 1 is 98% according to the validity conversion, the value is included in the valid category but requires improvement in the language element.

The average score of validators 2 is 97% according to the conversion of validity, the value is included in the valid category but requires improvement in the elements of presentation and language. Conclusion The notes on the validation results cover two aspects, namely language elements and presentation of material with details, language needs to be simplified (remove unnecessary words) for deaf students. Presentation of material the delivery of material is good enough but it is better if there is an incorporation of concrete images. Based on the comments and suggestions given by the material experts, the following is presented before and after the improvements made to the linguistic aspects in Figure 2 before the revision and Figure 3 after the revision of the linguistic aspects.

Figure 2. Before the improvement of linguistic aspects

Figure 3. After the improvement of linguistic aspects

The language style for deaf students needs to be as simple as possible, considering the impact of deafness, one of which is limited understanding of complex language (As Satillah et al., 2024). Simple language makes learning materials more accessible to deaf children, so they can actively participate in the learning process. It also helps teachers to convey information in a more effective way (Bustamin et al., 2023; Murwanti & Syefriani, 2024).

Based on the comments and suggestions given by the material expert, the following is presented before and after the improvements made to the presentation aspect of the material in Figure 4 before revision and Figure 5 after revision of the material presentation aspect.

Figure 4. Before the improvement of material presentation aspects

Figure 5. After the improvement of material presentation aspects

Media Expert Validation

Media experts aim to provide validation of GBL media, namely the presentation aspects and feasibility of GBL learning media energy source material. The average percentage is 94%. According to the validity conversion table, this value is included in the valid category, but needs a little improvement, namely color selection, especially on setting icon icons such as start/play, settings, volume, and subtitles. Based on the comments and suggestions given by the media expert, the following Figure 6 is presented before the improvements made regarding the color selection on the setting icons. Figure 7 explains the improvements made regarding the color selection on the setting icons in media.

Figure 2. Before the improvement of visual appearance aspects

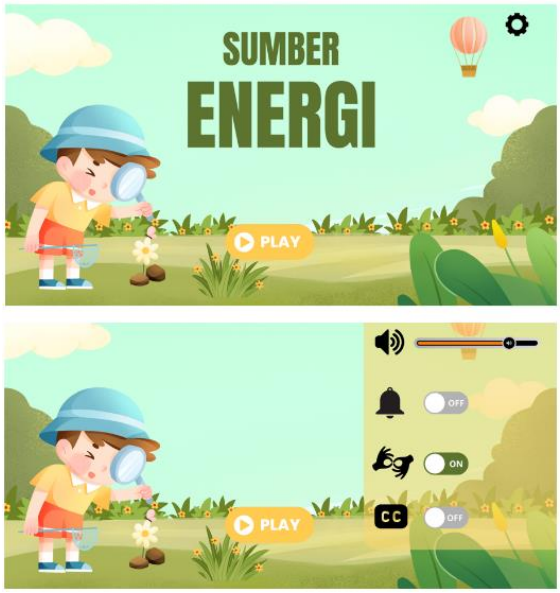

Figure 3. After the improvement of visual appearance aspects

Implementation

After making product improvements on GBL media, the next stage is the limited implementation of the product in the field by involving seventh grade students at one of the special schools in Bandung city consisting of 7 deaf students. The implementation was carried out for 5 days. Table 2 describes the results of the implementation of GBL on Deaf students in grade seven at a special school in Bandung city.

During the implementation process, students seemed more enthusiastic in the learning process, this is because the learning needs of deaf students as visual creatures can be met. 5 of 7 deaf students show self-confidence when

successfully completing missions in this energy source GBL media, this is in line with the opinion of (Widayati et al., 2023) who states that through GBL students will have increased self-confidence and children's self-esteem, if they successfully complete the game. The class teacher appears to be structured in carrying out the learning process through GBL which has been arranged by the teacher can be effective and efficient in presenting the subject matter because it can utilize the media properly and appropriately (Firmadani, 2020).

Table 2. Product implementation

No	Student initials	GBL Implementation Results					Total
		Material					
		Level 1 (Basic concepts Energy Sources)	Level 2 (Types of Energy Sources)			Level 3 (Utilization energy sources)	
			The Sun	Water	Wind		
		Day 1	Day 2	Day 3	Day 4	Day 5	
1.	M.R.W	70	62.5	75	62.5	67.5	67.5
2.	M.H.F	100	75	87.5	87.5	76.5	85.3
3.	M.R.T	70	75	62.5	62.5	67.5	67.5
4.	P.A.M	60	62.5	75	62.5	58.5	63.7
5.	L.A	70	87.5	75	62.5	67.5	72.5
6.	M.S.W	80	75	75	87.5	67.5	77
7.	B.D.P	50	62.5	62.5	75	67.5	63.5

Evaluation

In the evaluation stage, an assessment of the GBL media that has been developed and tested is carried out. The evaluation results are used to describe the validity of GBL media on energy source material. The validity of GBL media is based on the results of the assessment by material and learning media experts. The results of validation by material experts obtained a presentation of 97.5% with a valid category. The results of validation by learning media experts obtained 94% with a valid category, thus it can be concluded that the overall validation results obtained a presentation of 95.7% with a valid category. The following presents the percentage results of validity by experts in Table 3

Table 3. Validator score presentation

No.	Expert Validation	Percentage	Description
1.	Material	98%	Valid
2.	Material	97%	Valid
3.	Media	94%	Valid
	Average	95.7%	Valid

Evaluation of understanding of energy sources was carried out through pretest and post test stages. Table 4 explains the results of the pretest on grade VII students regarding the understanding of energy sources before being given an intervention using GBL media and table 5 explains the results of the posttest on grade VII students regarding the understanding of energy sources after being given an intervention for 5 days using GBL media. Figure 8 shows a graph of the pretest and posttest results of deaf students on the material on energy sources. Interventions are given in stages because each student has a different learning speed (Ikhsan & Leonardi, 2024). Gradual intervention also focuses so that each goal in the learning material can be achieved optimally.

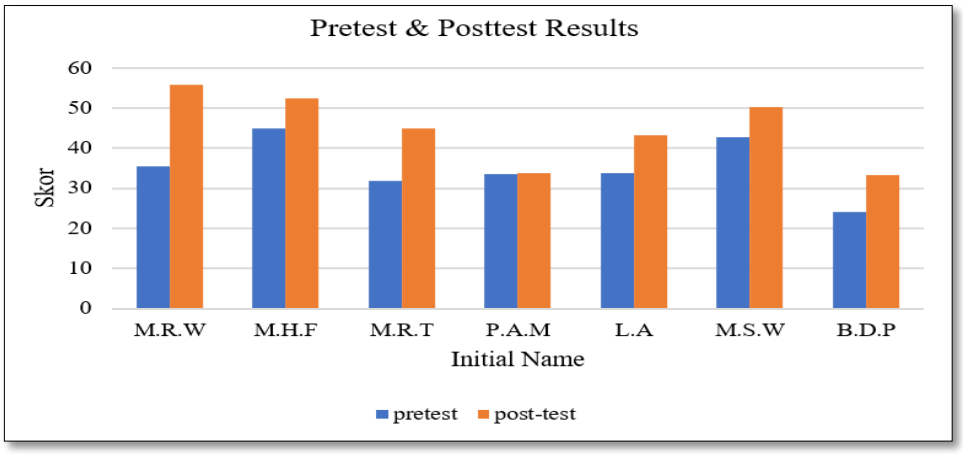

Figure 8. Pre-test and post-test result

Table 4. Pretest results of students' understanding of energy source material

No.	Student initials	Pretest Results on Energy Source Material					Total
		Material					
		Level 1 (Basic concepts Energy Sources)	Level 2 (Types of Energy Sources)			Level 3 (Utilization energy sources)	
			The Sun	Water	Wind		
1.	M.R.W	50	24.9	33.2	24.9	45	35.6
2.	M.H.F	70	24.9	33.2	33.2	63	44.8
3.	M.R.T	40	24.9	24.9	24.9	45	31.9
4.	P.A.M	40	24.9	33.2	24.9	45	33.6
5.	L.A	40	24.9	24.9	24.9	54	33.7
6.	M.S.W	60	33.2	33.2	33.2	54	42.7
7.	B.D.P	30	8.3	24.9	33.2	24	24
				Total			35%

Table 5. Post-test results of students' understanding of energy source material

No.	Student initials	Posttest Results on Energy Source Material					Total
		Material					
		Level 1 (Basic concepts Energy Sources)	Level 2 (Types of Energy Sources)			Level 3 (Utilization energy sources)	
			The Sun	Water	Wind		
1.	M.R.W	90	33.2	33.2	33.2	90	55.92
2.	M.H.F	90	33.2	33.2	33.2	72	52.32
3.	M.R.T	70	33.2	33.2	24.9	63	44.86
4.	P.A.M	70	24.9	33.2	33.2	63	44.86
5.	L.A	70	24.9	33.2	24.9	63	43.2
6.	M.S.W	80	33.2	33.2	33.2	72	50.32
7.	B.D.P	60	24.9	24.9	33.2	24	33.4
				Total			46%

The results of the pretest and posttest on deaf students show an increase in understanding of energy sources, table 6 shows the average results of the increase in understanding of deaf students on energy source material. The improvement of learning outcomes of deaf students in this study was influenced by the GBL learning media that had been designed so that a teacher can be effective and efficient in presenting lesson materials if they can utilize the media properly and appropriately (Firmadani, 2020). the use of technology in learning media has also been shown to increase students' interest, enthusiasm, and motivation in the teaching and learning

process. In today's modern era, games are no longer considered a negative impact on children, but games can improve thinking patterns and can also affect children's intelligence. One type of game that can hone children's intelligence is educational games. Based on the description that has been explained previously, it can be said that this educational game has a positive impact on children's development in understanding problems and solving these problems. The evaluation stage in this research not only focused at the end but at the end of each stage. Evaluation is carried out at each stage in the development process aimed at revision needs (Lailia, 2019). If the learning media has gone through the evaluation stage, the GBL learning media in the research is ready to use. Table 6. Average increase in student understanding of energy source material

Table 6. Average increase in student understanding of energy source material

Number	Student Initials	Pre-test Results	Post-test Results	Average
1.	M.R.W	35.6	55.92	45.76
2.	M.H.F	44.86	52.32	48.59
3.	M.R.T	31.94	44.86	38.4
4.	P.A.M	33.6	33.86	33.73
5.	L.A	33.74	43.2	38.47
6.	M.S.W	42.72	50.32	46.52
7.	B.D.P	24.08	33.4	28.74
		Average		40%

CONCLUSION

The development of GBL media to improve students' understanding of energy source material was carried out through five stages, including the analysis stage with the results of empirical and theoretical findings that GBL media can help deaf students to understand, motivate, and meet their learning needs. The design stage produced a GBL plan that was adjusted to the characteristics and learning styles of deaf students as visual creatures. The development stage is completed with validation to media and material experts with a percentage of 94%; 97%; 94% with a total average of 95.7% which can be concluded that this GBL media is valid for deaf students. The implementation stage shows an increased student learning response and a learning environment atmosphere that is able to motivate students to be more active in the learning process. The evaluation stage showed that GBL learning media to improve understanding of energy source material for deaf students in grade VII was declared valid and practical to use, in addition it can be concluded that through GBL the abilities of deaf students in grade seven at a special school in Bandung City increased by 40.03%. The development of Game-Based Learning (GBL) media for deaf students shows significant potential in improving understanding of energy source material, which can be an innovative model in inclusive education and encourage the use of educational technology that is more adaptive to the needs of students with learning disabilities.

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