Waste to Energy (WtE) as the basis for developing physics learning materials

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Abstract. Many social and environmental issues that the world of education can respond to. One of them is learning physics. One issue that is still a problem is urban waste. This paper aims to describe the development of physics teaching materials by using the waste to energy issue as a learning context. The method used is Research and Development with ADDIE design. This study shows that: (1) student literacy about waste to energy is still low so it needs to be improved (2) The design of physics teaching materials must contain four literacy domains namely content, process, context and attitude (3) Physics teaching materials in the context of waste to energy is declared feasible to use (4) The results of limited implementation in several schools show positive results and (5) Further development is needed to get teaching materials that are simpler, flexible, easy to learn, easy to understand and easy to study. This study concludes that we can present many social topics as the application of the main principles of physics, one of which is Waste to Energy by integrating it in physics learning. Integrated physics teaching materials are proven to improve student literacy on the issue of waste to energy.

1. Introduction
Waste is still a problem in Indonesia, one of which comes from municipal solid waste (Municipal Solid Waste). Based on MEF 2016 data, the percentage of MSW sources in Indonesia in 2013, 48% of households, 24% of traditional markets, 9% of commercial areas, 7% of roads, 6% of offices, 4% of schools, 4% of schools, and 2% of others [1]. The problem of urban solid waste in Indonesia forces the government to accelerate the development of waste technology into energy [2]. However, most of the problems of municipal waste are community behavior. Therefore, community participation is the center of success in the management of urban solid waste [3]. Analysis of the identity and significance of the community helps in showing the features of the community that can play an important role in resolving the problem of managing household solid waste in Indonesia [4].

Handling environmental issues and sustainability issues in municipal waste management must involve the community in them [5], one of them is through The Public-Community Participation (PCP) system [6] or Community Based Movement [7]. Increasing the role of the community can be done through increasing community literacy, both counseling, education and training [8] and mentoring [9]. One part of society that needs serious attention is students at all levels, from kindergarten to college [10]. They contribute 4% of the volume of municipal waste. Increasing their literacy is expected to
influence the literacy of their families and communities. The pattern of increasing student literacy can be done through special programs, or can be integrated in learning, one of which is physics [11].

Physics plays a major role in shaping the profile of students who care about their environment and in turn will form a civilized communal society [12]. To achieve this, meaningful and quality physics learning is needed [13]. Learning that is close to students, which facilitates the discovery of real concepts and experiences that are integrated and integrated with the environment and social culture in which they live [14]. Integration of waste and environmental issues can be integrated in the planning, implementation and evaluation of learning included in teaching materials. This paper aims to reveal waste to energy-based physics teaching process.

2. Method
The research method used is Research and Development (R & D) with ADDIE design (Analysis, Design, Development, Implementation and Evaluation). The ADDIE model is the most common model used for creating instructional materials [15]. The ADDIE model was first compiled by Gagné in 1967 and placed in a more formal format by Briggs (1970) while working on several military training-based projects. The ADDIE label, does not appear in the literature published until 1975 [16].

The Analyze is the phase of all other phases of instructional design [17]. This stage contains an analysis of needs derived from analysis of the problem and potential solutions. The problem in this study is the low scientific literacy of students towards Waste to Energy (WTE). While the potential in this study is the potential of natural resources and the environment contained in the environment around students, one of which is Garbage Incineration Plants (GNP). The solution offered is the preparation of physics teaching materials that discuss GNP.

The Design Phase requires aligning what is found in the need’s analysis phase with the actual structure of the learning content. The design phase has two main characteristics: systematic and specific [18]. The design phase is the stage of making a design. This design is a systematic process carried out to compile a product design that will be developed starting from designing product arrangements, designing product content and designing product material. The product made in this research is physics enrichment material which is developed as a physics learning tool.

Development is a useful phase because the results are concrete and visible. This stage includes content development and content chunking, content creation, development of learning objects, student assessment and additional resources [19]. The preparation of the contents of the teaching materials of the design results that have been made in the previous stage will be developed so that it becomes more complete teaching material. After the teaching materials are developed, the next step is to do validation by content experts, construction experts and linguists. Input from experts is used as a reference to perfect teaching materials. Besides that, it was also seen how the opinions of students in aspects of readability.

The implementation phase consists of delivering the instruction. The delivery can be sent to the instructions format previously listed [20]. Implementation is the stage where the product that has been developed will be implemented in a real situation that is in the class. Testing of this enrichment material uses the pre-experimental method with the design of one group pretest posttest design [21]. The aim is to compare the conditions before and after being treated.

The final phase is evaluation. This phase measures the effectiveness and efficiency of instructions. Evaluation must really occur throughout the entire learning design process - in phases, between phases, and after implementation [17]. This stage is the stage to see the results of research and development that has been done.

3. Result and discussion

3.1. Results of need assessment
Table 1 below shows the results of the initial study of students' literacy profiles of waste to energy. This data is obtained using literacy instruments with 4 domains, namely process, concept, context and attitude.
Tabel 1. Student's initial literacy profile.

| Literacy Domain | Close school score | Far school score |
|-----------------|--------------------|-----------------|
| process         | 1.95               | 1.92            |
| concept         | 0.90               | 0.16            |
| context         | 1.69               | 2.16            |
| attitude        | 2.77               | 2.54            |
| average         | 1.83               | 1.70            |

The data above shows that student literacy towards WTE is still low. Low literacy is caused by a lack of information, knowledge and learning experiences both formal and informal. Efforts are needed to improve their literacy, one of them is through the development of contextual WTE physics teaching materials.

3.2. Design and development results
WTE-based physics teaching materials are prepared based on 4 literacy domains, namely: process, concept, context and attitude.

In the process aspect, this physics teaching material contains a description of how waste is converted into energy starting from sorting, collecting, plant, waste process, to producing energy in the form of heat, gas and electricity. In the concept aspect there will be discussed several physics concepts that exist in the waste to energy process such as force, pressure, fluid, energy, thermodynamics, electricity and others. In the context aspect, it is discussed further about the waste to energy context which is limited to municipal solid waste, such as understanding, waste management, waste generation and characterization, energy from waste: thermal processing, biochemical processing, and chemical processing [22]. In the attitude aspect, we will discuss how to reduce the negative impact of WTE, especially the environmental and social aspects.

After the teaching material has been compiled, the next step is to assess whether the teaching material is appropriate or not. Table 2 below shows the average results of expert validation and the level of readability of students' perspectives regarding waste-to-energy physics teaching materials.

Tabel 2. Expert and student assessment of learning materials.

| Domain literacy | Expert Perspective | Students Perspective |
|-----------------|--------------------|----------------------|
|                 | score | category | score | category |
| content         | 73.41 | good     | 84.16 | very good |
| packaging       | 69.99 | good     | 78.04 | good     |
| language        | 74.00 | good     | 82.52 | very good |
| Graphic         | 72.50 | good     | 81.57 | very good |

Based on the assessment provisions sourced from the center of the curriculum and books, the enrichment materials assessed by these categories are valid and suitable for use in learning activities [23].

3.3. Results of implementation and evaluation
To see the effectiveness of physics teaching materials in improving student literacy on waste to energy, limited trials were conducted in two schools, schools that were close to GIP locations and distant schools. The selection of these two places is at the same time to see whether there are differences in the level of literacy of students seen from their close proximity to the source of information. The results of these trials are shown in table 3.
Tabel 3. Effectivity (N-Gain analysis).

| School                      | N-Gain | category |
|-----------------------------|--------|----------|
| X (close to location)       | 0.48   | medium   |
| Y (far from location)       | 0.40   | medium   |

Based on Table 3 above, it can be seen that the N-gain obtained from both classes is 0.48 and 0.40. If you look at the criteria proposed by Hake (1999), the increase in student literacy is in the moderate category [24].

4. Conclusion

We can present many social and environmental topics as the application of the main principles of physics, one of which is Waste to Energy. Through the integration model, Waste to Energy can be used as a context in the development of physics teaching materials [25]. Physically prepared teaching materials have been proven to improve student literacy.

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