

Evaluation of Learning Media Creation Based on Results of Computational Chemistry Calculations Visualised

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Abstract

The objective of this study is to determine the outcomes of the requirements analysis and learning materials for electrolyte and non-electrolyte solution materials. Additionally, learning materials will be developed utilizing computational chemical calculations and visualization of the results to create learning media based on the National Education Standards Agency (BSNP) requirements. This kind of study uses the ADDIE development model and is referred to as development research. There are five steps in the current ADDIE model: analysis, design, development, implementation, and evaluation. The entire student body of one of the senior high schools in Padangsidempuan City, North Sumatra, Indonesia, served as the study's population. The participants in this research were senior high school students from Padangsidempuan City, North Sumatra, Indonesia. Use of a purposive sampling technique yields grade X as the research samples . An inquiry form derived from the National Education Standards Agency used as the research tools . Utilizing a significance level of 5%, the data analysis was conducted using the SPSS 22 for Windows software . The investigation's findings demonstrate the need for educational materials that can help pupils who struggle with learning . Based on 95% validation findings , the learning materials for both electrolyte and non- electrolyte solutions visualise the outcomes of computational chemical calculations .



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1. Introduction

Presently, developments are appropriate with knowledge in information and technology communication, which is the optimal use of the computer in activity learning. To increase quality education, it is also necessary to use effective teaching media. Powerpoint is the only media that can used, and the associated presentation format with computing is known as chemistry computing (Hasibuan, et al., 2020). Learning about chemistry and topics related can developed by

utilising a material learning-based computer (Ozmen, 2008). Media-based computers will demand students active, easy students understand and follow lesson solution electrolytes and nonelectrolytes that can increase results learning (Tambunan & Sianturi, 2012).

There are several applications available for computational chemistry that can make it easier for students to understand the lesson and make it more effective. Utilizing chemistry using animation can improve academic performance and a strong understanding of the characteristics of materials (Karacop and Donymus, 2013). The use of computational chemistry using a variety of software programs, including NwChem, Hyperchem, and Chems sketch, allows almost any practical chemistry material, whether at the beginner or advanced level, to be modelled (Fortenberry, et al., 2015).

The benefits of using computerized chemical modelling include low cost, high level of accuracy, fast training time, lack of danger, and maximally increasing chemical knowledge (Ochterski, 2014). There are several applications for the use of computing in chemistry that are used to make it easier for students to remember chemical structures and chemical bonds. Valiev et al. (2010) explained that NWChem is a collection of chemical computational tools that offers various methods for analyzing the structure of molecular systems and carrying out periodic tests using electrochemical equations. One of the central issues in chemistry education is in the learning process for students to solve problems conceptually, not just apply mathematical equations. Research in the field of chemistry education has shown that students tend to learn and solve computational problems but often do not understand the deeper conceptual aspects of chemistry and the reasoning necessary to be more creative and flexible in problem-solving. While students often succeed on problems that are very similar to those depicted in textbooks or demonstrated in the classroom, students tend to solve problems with problems that can be solved with similar techniques (McLaren, 2007).

In computational chemistry, it can be modified into animation using software Chems sketch, Jmol, ChemDraw, and Avogadro. The integration of visual aids and active learning strategies in chemistry programs can help the public become more knowledgeable about chemical relationship theory (Frailich, 2008). Integrating other computing programs such as ChemDraw and Chems sketch into PowerPoint devices can increase interest in learning media (Febriani and Aini, 2020).

The previously used learning media used by the teacher did not display compound structures related to electrolyte and non-electrolyte solution compounds, which made it difficult for students to understand and remember the compounds and molecular shapes of several

electrolyte and non-electrolyte solution compounds. So learning media is needed that can show the molecular shape of several compounds in the material, such as the structural shape of the compounds NaCl, HCl, HF, and others. Using learning media based on visualization of the results of computational chemical calculations will attract students' attention in teaching and learning activities, making it easier for students to remember and improving student learning outcomes (Anggraini et al., 2018).

Developing learning media is the single most effective strategy for increasing student motivation and quality of learning. When learning material and principles are understood in detail, conditions are created that enable students to apply knowledge, skills and knowledge, as well as skills and attitudes effectively (Anggraini et al., 2018). The use of computerized media will make it easier for teachers to explain abstract material in a way that is easy to understand and useful for students (Yona et al., 2016). To know the results of the needs analysis and learning media commonly used by teachers in schools in learning electrolyte and non-electrolyte solutions.

Instructional Media

According to Asyhar (2011), the use of media can increase students' understanding because it can increase their motivation and attitudes towards class material. In contrast, Gafur (2012) argues that the role of media in education falls into two categories: as a tool for classroom instruction and as a tool for independent learning without a teacher. Media as a tool for learning has a clear statement that the use of media depends on the teacher being studied.

The most effective form of educational media is visual media, which can attract attention to learning content and connect it to the real world. Visual media should always be used in an appropriate context, and viewers should engage with the visuals to ensure information processing. Some visual-based media are more engaging than others because they have images that help people understand them.

Computer-based media is the process of creating and distributing content using digital-based data. Simulating with a computer will create a fun and interactive atmosphere with other people. Success is due to scenarios, dashboard models, and layer teaching. So the use of computer-based media requires a thorough understanding of designing learning designs, preparing supporting equipment, and using learning media (Arsyad, 2014).

Media functions in the field of education as a learning tool that continuously pays attention to the character, environment and learning community that have been discussed and recorded by the teacher. According to Setyosari (2012), using media is the single most important component

in the education system; even more specifically, media use can be seen as a problematic component of educational initiatives. Without learning media, the educational process will not be able to run successfully. According to Sanjaya (2008), educational media has: 1) Identifying certain objects or evidence, such as long-lasting objects that can be captured with a camera, on film, or through audio or video recordings, so that they can be used as needed. 2) Manipulating certain situations, beliefs, or target objects. A teacher can present a more general but more specific lesson plan using teaching aids such as a computer. For example, lesson plans on diagonal cubes can be presented using computer-based teaching aids. 3) Increase students' motivation and enthusiasm for learning. Use of media to inspire students to learn. 4) The following are some of the practical capabilities of media used in education: (a) media as a solution to teacher and student conflicts; (b) avoiding learning disruptions; (c) building relationships between teachers and students; (d) the media can present accurate and up-to-date statements of fact; (e) media can inspire and encourage student activities; (f) Monitoring student learning speed; and (7) as feedback

Development Research

Development research is used in developing products, designs and activity steps in the field of education, specifically focusing on the field of design, such as media and educational activities (Setyosari, 2012). Development research can be described as a procedure to update and evaluate a product in use, it can also be described as a method to produce a particular product and measure its efficacy.

According to Akker (2006), the objectives of this research were modified based on the following: 1) Curriculum as a process of delivering information and disseminating decisions during the development of a product or a particular field, an effort to improve it and make it more capable of expressing various ideas in remote situations. 2) Technology and media. The goal is to improve the way instruction, brainstorming, and evaluation are conducted by using other situations or more general approaches to solving specific problems. 3) Education and teaching. Curriculum formulation, assessing success from observation and learning, development in designing the learning environment, as well as playing a role in basic scientific understanding, are the goals of this program. 4) Teacher Education The goal is to provide professional development for teachers and encourage change in certain areas of educational technology.

According to Lastari (2018), development steps begin with analysis, planning, development, implementation and evaluation. Specifically, several parts of the ADDIE development model: 1) Analysis stage, namely the researcher's analysis activities, there are three types: competency analysis, student character, and instructional. 2) Design Stage Consists of three types of work that must be done: creating a blueprint for the educational media that will be

created, building a system to expand educational media, and evaluating the tools used in educational media (Lastari, 2018). 3) The development stage, namely learning in the media has begun to develop based on design activities. Next, determine and assess the media that will be needed. The primary procedure often mentioned is producing content, including gathering supporting media, developing guides for teachers, developing staff biographies, conducting format reviews, and producing a final product (Branch, 2009). 4) Implementation stage, namely the learning that has been developed is applied to students, with the participation of teachers and students. 5) Evaluation stage, namely evaluation used on this special day to correct several teachers who misinterpreted the lesson material. Evaluation is given in the context of feedback on learning and assessment provided through learning indicators (Lastari, 2018).

2. Method

Study development is the type of analysis used. According to Angko & Mustaji (2013), the method of evaluation of products used in industry manufacturing is used to produce product targets and assess the effectiveness product. According to Sugiyono (2015), the method of data collection and development is viewed as an ethical way to evaluate the quality of products that have been produced.

Method analysis with the ADDIE development model (Analysis, Design, Development, Implementation and Evaluation). The ADDIE model Now uses five stages in Figure 1.

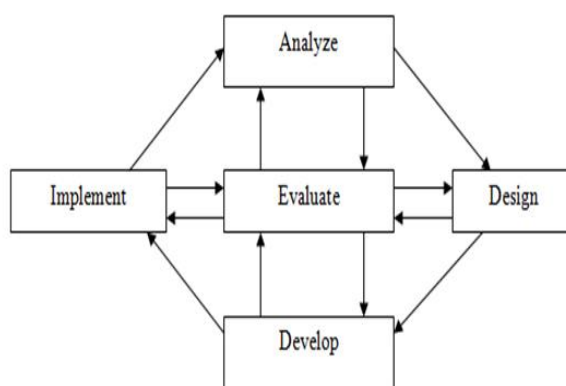


Figure 1. ADDIE Research Stages (Sugiyono , 2015)

The research population is all class X students who will study electrolyte and non-electrolyte material. The current research sample consists of 30 students at one of the high schools in the city of Padangsidempuan in class X. Purposive sampling was used in the process of determining the

sample class. Two professional media lecturers and two professional material teachers validated the media that had been developed.

Development of learning media with steps and media research design based on visualization of NWChem calculation results using the ADDIE development model with the following paradigm:

Analysis Stage: Analysis activities to understand the problems students face when learning electrolyte and non-electrolyte solutions. So you can design media that helps solve problems experienced by students.

Design Stage: Designing the initial product by carrying out activities (1) designing the learning media to be created; (2) designing instruments to be used such as questions, questionnaires and validation instruments ; (3) designing the compounds to be made; and (4) compiling teaching materials. The results of this stage are instruments, structures of electrolyte and non-electrolyte solution compounds, teaching materials, and learning media based on visualization of the results of computational chemistry calculations.

Development Stage: (1) Creation of compound structures with NWChem, namely the compound structures of NaCl, HCl, NaOH, HF, H₂S, NH₃, H₂O, CH₃OH, C₂H₅OH, and C₆H₁₂O₆; (2) Compound visualization with Avogadro and Jmol ; (3) Making an animation with PowerPoint; (4) Validation of learning media for two media expert lecturers and teaching materials for two chemistry teachers; (5) Trial of chemistry learning media; (6) Improvement of learning media and teaching materials; (7) Final product of learning media; (8) Making instruments; (9) Instrument validation; and (10) Final instrument product. The expected results at this stage are learning media based on visualization of the results of computational chemical calculations developed by the National Education Standards Agency (BSNP).

3. Results

Analysis

Observation results about the need to teach chemistry in schools and provision of facilities support learning in schools, teachers use book package chemical as a source for teaching chemistry in class, school provide projector to supporter smoothness activity Study teach. Based on observations and interviews provided by the chemistry teacher show that activity Study taught using the media that teachers still use is not optimal because there are still Lots of students who score chemistry low or do not pass the Criteria Minimum Completeness already in place namely 80.

Because of that, the need for learning media in the material solution electrolytes and non-electrolyte solutions caused students difficulty in understanding draft material and understanding chemistry structure. So learning media is needed chemistry based visualization results calculation chemistry in matter solution electrolytes and non-electrolytes, in enhancement results and motivation Study student.

Design

Create media designs and visualize NWChem calculation results with the Jmol application to obtain animations and 3D molecular shapes of several compounds.

Learning Media Product Design Design



The design stage of learning media product design is preparing chemistry learning materials on electrolyte and non-electrolyte solutions, learning objectives, learning indicators, summaries and learning evaluations. Designing 40 objective test items and 30 motivation questionnaire statement items.

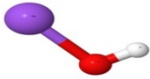
Visualization Stage of Computational Calculation and Software Results Jmol

After the learning media product design stage was completed, researchers identified several compounds that were suitable for the electrolyte and non-electrolyte materials that would be used to make them. After the compound is determined, computational calculations will then be carried out using software NWChem and using software Jmol to get visualization and animation of these compounds.

Software calculation results in NWChem Version 6.6 to obtain geometric optimization of the Compound method using the 3-21G basis set. Data results for calculating strong electrolyte solution compounds using software NWChem can be visualized using software The number of moles is in 3-dimensional (3D) form which can be seen in Table 1.


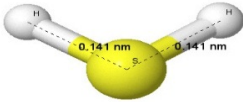
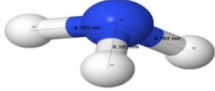
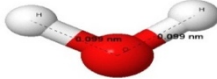
Table 1 . Visualization of the 3D structure of strong electrolyte solution compounds using software Jmol.

No	Compound Name	3D Structure Visualization
1.	Sodium Chloride (NaCl)	
2.	Hydrochloric Acid (HCl)	

3.	Sodium Hydroxide (NaOH)	
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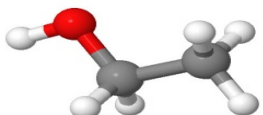
Result of calculation compound solution electrolyte weak using NWChem software can visualized using Jmol software in 3 Dimensional (3D) shapes that can be seen in Table 2.

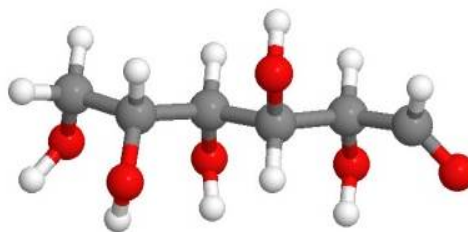
Table 2 . Visualization of the 3D structure of weak electrolyte solution compounds using software Jmol .

No	Compound Name	3D Structure Visualization
1.	Hydrogen Fluoride (HF)	
2.	Hydrogen Sulfide (H ₂ S)	
3.	Ammonia (NH ₃)	
4.	WATER (H ₂ O)	

The results from calculating non-electrolyte solution compounds using software NWChem can be visualized using software The number of moles is in 3 Dimensional (3D) form which can be seen in t-table 3.

Table 3 . Visualization 3D structure of compounds non-electrolyte solution using Jmol Software

NO.	Compound Name	3d Structure Visualization
1.	Methanol (CH ₃ OH)	
2.	Ethanol (C ₂ H ₅ OH)	

3. Glucose (C₆H₁₂O₆)**Validation Data**

At this stage, learning media based on visualization of the results of computational chemistry calculations on electrolyte and non-electrolyte solution materials is validated using modified National Education Standards Board (BSNP) eligibility standards. The analysis was carried out on 4 validators, namely 2 chemistry teachers as material expert validators and 2 chemistry lecturers as media expert validators. The media developed is assessed based on three appropriateness standards according to BSNP, namely appropriateness of content, appropriateness of language, and appropriateness of presentation.

The level of learning media for electrolyte and non-electrolyte solutions developed by BSNP including feasibility, language and presentation is shown in Table 4 and Figure 2.

Table 4. Feasibility Analysis Results of Learning Media Based on Visualization of Computational Chemical Calculation Results

No.	Aspect Evaluation	Value Percentage	Qualification
1.	Content Eligibility	95%	Very Worth It
2.	Language Eligibility	96%	Very Worth It
3.	Appropriateness Presentation	94%	Very Worth It

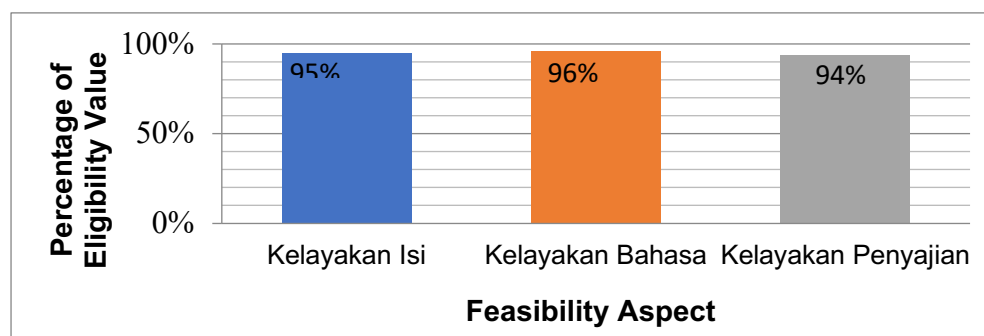


Figure 2. Graph of Feasibility Analysis Results of Learning Media Based on Visualization of Computational Chemistry Calculation Results

From the table and figure above, the results of the analysis of electrolyte and non-electrolyte solution learning media developed based on the BSNP questionnaire are content suitability with an average percentage value of 95%, meaning the media is very suitable and does not need revision, language suitability with an average percentage value 96% means that the media is very suitable and does not need revision, and the presentation feasibility average percentage value is 94%, meaning that the media is very suitable and does not need revision. From the average percentage value for these three aspects, it is obtained that 95% means that the media is very suitable for use. The three aspects of the feasibility of the media being developed will be described as follows:

1. Content Eligibility

The assessment was carried out by two material expert validators, namely chemistry teachers from two schools different in Padangsidempuan City using a modified BSNP questionnaire. The advice from the material expert validator is that the material presented is complete and sequential according to the indicators and learning objectives. The results of the analysis of electrolyte and non-electrolyte solution media that have been developed based on content suitability are shown in Table 5 .

Table 5. Results- Analysis. Feasibility. Content. Media. Learning Based on Visualization of Computational Chemical Calculation Results .

No.	Validator	Amount	Percentage of Eligibility Value	Average value Percentage
1.	Validator 1	64	94%	95%
2.	Validator 2	65	96%	

From the table above, based on the content feasibility analysis of the media developed referring to BSNP, the content feasibility percentage value from the first validator was 94% and the second validator was 96%, and the average content feasibility percentage value was 95%. These results indicate that the electrolyte and non-electrolyte solution learning media that has been developed is very suitable for use and does not need to be revised.

2. Language-Eligibility

The assessment was carried out by two material expert validators using a modified BSNP questionnaire. The suggestion from the material expert validator is that the language used in the media should be in a language that is easy to understand and that there should be no repetition of words in one sentence. The results of the analysis of electrolyte and non-electrolyte solution media that have been developed based on language appropriateness are shown in Table 6.

Table 6. Results of Feasibility Analysis of Learning Media Language Based on Visualization of Computational Chemical Calculation Results

No.	Validator	Amount	Value Percentage Appropriateness	Average Percentage Value
1.	Validator 1	47	98%	96%
2.	Validator 2	45	94%	

From the table above, based on an analysis of the appropriateness of the language in the media developed referring to BSNP, the percentage value of language appropriateness from the first validator was 98% and the second validator was 94%, and the average value of the percentage appropriateness of the language of the media was 96%. These results indicate that the electrolyte and non-electrolyte solution learning media that has been developed is very suitable for use and does not need to be revised.

3. Feasibility-Presentation

The assessment was carried out by two media expert validators, namely chemistry lecturers at Medan State University (validator 3 and validator 4), using a modified BSNP questionnaire. Advice from media experts is that there should be a slide about concept maps, and from the concept map, click on the one that relates to the material to be discussed. And so that the shape of the NH_3 molecule is corrected again so as not to cause misconceptions. The results of the analysis of electrolyte and non-electrolyte solution media that have been developed based on presentation feasibility are shown in Table 7 and Figure 3.

Table 7. Results Analysis Appropriateness Presentation Media Learning Based on Visualization of Computational Chemical Calculation Results

No.	Validator	Amount	Value Percentage Appropriateness	Average Percentage Value
1.	Validator 1	73	96%	95%
2.	Validator 2	71	93%	
3.	Validator 3	72	95%	92%
4.	Validator 4	68	89%	
Total Value Average Percentage				94%

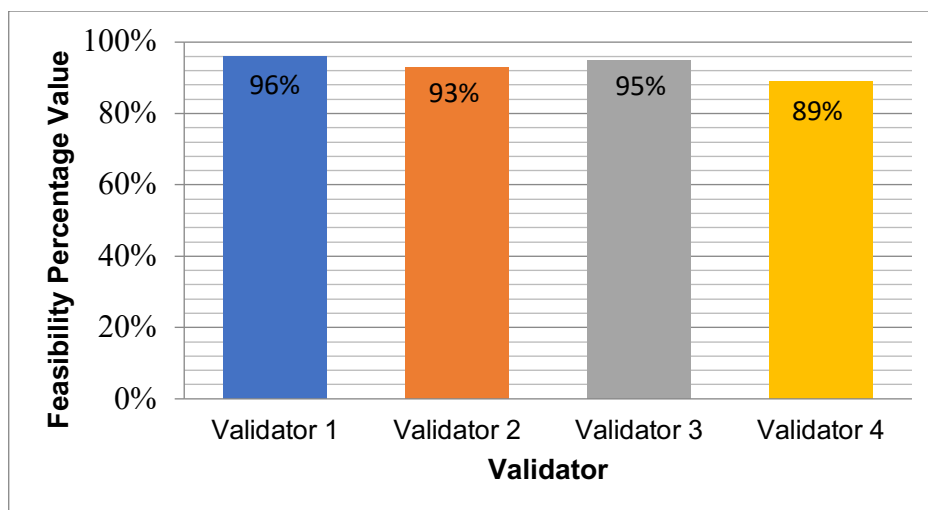


Figure 3 . Graphics of Analysis Results for Presentation of Learning Media based on Visualization of Computational Chemistry Calculation Results

From the table and figure above, based on an analysis of the feasibility of presenting the media being developed, refer to In BSNP, the presentation feasibility percentage value obtained from the first validator was 96%, the second validator was 93%, the third validator was 95% and the fourth validator was 89%. So the average value of the percentage of appropriateness of media presentation is 94%. These results indicate that the electrolyte and non-electrolyte solution learning media that have been developed are very suitable for use and do not need to be revised.

4. Discussion

Based on the results of interviews conducted with teachers, it was found that students' chemistry learning outcomes were still low due to difficulties in understanding chemical concepts and structures on the subject of electrolyte and non-electrolyte solutions, so media were needed to solve student problems. Next, the researchers designed learning media that used animation by utilizing technological developments in the media creation process. Learning media based on visualization of the results of computational chemical calculations developed is integrated with PowerPoint. PowerPoint was chosen because the application has complete features and is available on every computer so it can be used by anyone, anywhere and anytime.

After the development of teaching materials is carried out, a feasibility test of the content, language and presentation is carried out by the lecturer as a media expert validator and the chemistry teacher as a material expert validator. From the results of the media assessment based on the modified BSNP, it was found that the suitability aspects of the content, language and presentation of the learning material were very suitable for use or did not need revision. The

average percentage value for content appropriateness was 95%, language 96%, and presentation 92%.

Wilhelm's research (2016), using animation in learning can help students understand chemical structures, namely Lewis structures, Sintiani research, et al., (2020) said that learning media based on 3-D visualization and animation is very suitable/valid used for chemistry learning. Research by Hadisaputra et al., (2017) stated that the chemistry teaching and learning process using computational chemistry can be better optimized.

Based on the learning media developed from visualization of molecules of electrolyte and non-electrolyte solution compounds, students can differentiate between ionic bond compounds and polar or non-polar covalent bonds based on the movement of the molecules, if the ionic bond compound, the movement force on the molecule is clearer or can undergo ionization (the splitting of the molecule into ions -ion), while the movement of the covalent bond in the molecule can be seen to undergo ionization, and non-polar covalent bonds experience a shift but because the movement force is small it cannot be seen clearly.

5 . Conclusion

After conducting research, data analysis and hypothesis testing, the researchers reached the conclusion that the validation results of the feasibility of learning media based on visualization of the results of computational chemical calculations on electrolyte and non-electrolyte solution materials based on BSNP obtained an average percentage of content feasibility of 95%, language 96%, and presentation 94%. From the average percentage value of these three aspects, it is obtained that 95% means that the media is very suitable for use.

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