12(2), 2023, 11-22 DOI: 10.23960/jppk.v12.i2.2023.02
Jurnal Pendidikan dan Pembelajaran Kimia
e-ISSN: 2714-9595| p-ISSN 2302-1772
http://jurnal.fkip.unila.ac.id/index.php/JPK/index

# Analysis of the Validity Level of Interactive E-Modules to Improve Visual-Spatial Intelligence on Molecular Shape

**Zulia Tris Febrianti[1], Kusumawati Dwiningsih[2]**

1,2 Sarjana Pendidikan Kimia, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Surabaya, Jl. Ketintang, Ketintang, Kec. Gayungan, Kota Surabaya, Jawa Timur 60231.

*Correspondinge-mail: zuliafebrianti118@gmail.com

*Received: June 1st, 2023 Accepted: June 19th, 2023 Online Published: August 1st, 2023*

**Abstract: Analysis of the Validity Level of Interactive e-Modules to Improve Visual-Spatial Intelligence on Molecular Shape.** The purpose of this research is to obtain the validity of interactive e-module learning media on molecular form material that can increase students' visual-spatial intelligence. This research uses a type of R&D (Research and Development) with the ADDIE development model. This development model consists of 5 stages, namely analysis, design, development, implementation, and evaluation. The research instruments used in this study were content validation sheets and construct validation sheets. Based on the analysis of the validation results that have been carried out, content validity obtained a percentage of 85% and construct validity got a percentage of 90% which was categorized as valid. Based on the results of data analysis that has been obtained, it can be concluded that the interactive e-module on molecular geometry material can be said to be valid for use as a learning medium that can improve visual-spatial intelligence.

**Keywords:** Interactive, E-Module, Learning Media, Molecular Geometry, Visual-Spatial Intelligence.

***Abstrak: Analisis Tingkat Validitas E-Modul Interaktif untuk Meningkatkan Kecerdasan Visual-Spasial pada Materi Bentuk Molekul.*** *Tujuan dari penelitian pengembangan ini adalah untuk memperoleh validitas media pembelajaran e-modul interaktif pada materi bentuk molekul yang dapat meningkatkan kecerdasan visual-spasial peserta didik. Validitas suatu media pembelajaran dapat dilihat dari validitas isi dan konstruk. Jenis penelitian ini menggunakan penelitian pengembangan atau R&D dengan mengaplikasikan model pengembangan ADDIE. Model Pengembangan ADDIE terdiri dari 5 tahapan yaitu analisis, desain, pengembangan, implementasi, dan evaluasi. Instrumen yang digunakan adalah lembar validitas isi dan lembar validitas konstruk. Berdasarkan analisis hasil validasi, validitas isi diperoleh persentase 85% dan validitas konstruk mendapat persentase 90% yang dikategorikan valid. Berdasarkan dari hasil analisis data yang telah diperoleh dapat disimpulkan bahwa e-modul interaktif pada materi geometri molekul dapat dikatakan valid untuk digunakan sebagai media pembelajaran yang dapat meningkatkan kecerdasan visual-spasial.*

***Kata kunci:*** *Interaktif, E-Modul, Media Pembelajaran, Bentuk Molekul, Kecerdasan Visual-Spasial.*

## ▪ INTRODUCTION

Chemistry is defined as the science of the composition and structure of matter and the changes that accompany it (Ainyn & Dwiningsih, 2021). These changes involve energy being released or absorbed during a chemical process. In studying chemistry, it is generally discussed about abstract concepts. This abstract nature makes it difficult for students to learn chemistry because the concept cannot be actualized, and must be drawn in the form of a schematic or model (Nurviandy et al., 2020). Concepts such as atomic structure, periodic table system, chemical bonds are a series of topics that require a deeper understanding by students. Particularly in the molecular shape sub-material which is abstract in nature and requires a strong conceptual understanding that requires spatial imagination and visualization of molecular representations (Saskia & Arief, 2020).

Chemistry can be studied easily if one can master the three levels of chemical representation, namely: the macroscopic level, the sub-microscopic level, and the symbolic level. The macroscopic level is the level of representation in the form of phenomena and facts in everyday life, macroscopic: as what is seen, touched and smelled. The sub-microscopic level refers to representation based on actual observation, but at the same time some theory is needed to describe what's referred to as molecular level for atoms, molecules, ions and structures. The symbolic level is the level of representation based on facts, transformed into simple symbols such as symbols of atoms, molecules and compounds in the form of pictures, formulas, equations, mathematical operations and graphics (Enero Upahi & Ramnarain, 2019).

Students find it difficult to understand abstract concepts in chemistry and also students have low visual-spatial abilities, especially in visualizing intermolecular interactions at the submicroscopic level (Rahmawati et al., 2021). Molecular shapes are easier to learn when students have a good understanding of them at the macroscopic, microscopic, and symbolic levels. For students to understand and learn chemistry easily, they need to master and integrate different levels of representation in chemical materials. This makes chemistry classified as a difficult subject for students, due to the various skills students need to understand chemical material. This statement is supported by early research with student questionnaires which shows that 66% of students are not interested in the learning process. Based on interviews with students, it was explained that in chemistry learning, especially in the molecular shape sub-material, the teacher only used textbooks and power points in the learning process. Chemistry learning that does not involve chemical representations in the learning process will cause students to have difficulty understanding the molecular shape material properly. Previous research has reported that students of all levels have difficulty learning chemistry due to their inability to visualise atoms or molecules (Erlina et al., 2021).

Chemistry learning which generally discusses chemical reactions is considered boring for students. This is because students only know chemical concepts from books and teacher explanations (Nurkholik, 2021). Based on the results of the preliminary study, it shows that through interviews with chemistry teachers, it shows that the level of completeness of students on chemical bonding material is still below 50%. The teacher still uses powerpoint and whiteboard as media to illustrate the shape of molecules in the learning process. The teacher also said that molecular shape material is a difficult material to teach because the teacher has to repeat the explanation so that students understand the material that has been explained in class. It can be interpreted that in the learning process visualisation of submicroscopic and symbolic levels of representation of molecular shape material has not been represented.

In the matter of molecular geometry explains the existence of molecular shapes that can affect molecular properties, such as interactions between molecules. The material characteristics of molecular shapes tend to be at the submicroscopic and symbolic levels (Tamami & Dwiningsih, 2020). This can be easily understood by students if they have good representation skills (Achuthan & Kolil, 2018). In the process of learning chemistry, visualization is also needed to understand the types of molecular shapes and their angles to increase students' understanding of molecular shapes. The ability to visualize molecular structure can bridge the gap between micro level and macro level understanding. It is certain that students will be able to understand chemical material if they have a good understanding of the level of chemical representation (Sukmawati, 2019). Representational skills and visualization processes in the chemistry learning process can both be linked to visual-spatial intelligence (Tamami & Dwiningsih, 2020).

Visual-spatial intelligence is one of the intelligences that allows a person to visualize information and process data and concepts into metrics and visual images. (Marnoufi et al., 2022). Visuspatial intelligence is also defined as the ability to accurately perceive the visual world, alter or modify perceptions, construct mental representations of visual information, and use those representations to perform activities (González Campos et al., 2019). Understanding the shape and orientation of three-dimensional objects correctly from their two-dimensional representation is known as visual-spatial ability (Isaloka & Dwiningsih, 2020). A study by Sunyono and Sudjarwo (2018) found that high school students' understanding remains at the macro level, and students still struggle to interpret models. Therefore, students' visual-spatial abilities need to be improved so that they can understand material at the submicroscopic and symbolic levels, such as molecular shape material. Students' visual-spatial intelligence can be improved in various ways in the learning process. There are three ways to improve visual-spatial intelligence, namely understanding molecular symmetry, being able to visualize molecular shapes, and changing molecular shapes from two dimensions to three dimensions (Achuthan & Kolil, 2018). Visual-spatial indicators cover several aspects, namely the aspect of rotation, the ability to imagine the movement of an object, symmetry, and the interpretation of 2D molecular shapes into 3D or vice versa, as well as the ability to imagine 2D or 3D molecular shapes (Asri & Dwiningsih, 2022).

The ability of students to solve problems in learning chemistry by using three levels of chemical representation can show the success of students in the process of learning chemistry (Farida et al., 2018), so that starting from this description, students' visual-spatial abilities in chemistry lessons must be developed. Therefore, we need a learning media that can provide solutions to these problems. To improve mastery of chemical concepts students can observe demonstrations of animation activities, study submicroscopic visual images, and build concepts through reasoning. This can happen if the learning process uses the right learning media (Sunyono & Meristin, 2018). Based on this description, a learning media is needed that can improve visuospatial intelligence by containing visuospatial indicators so that students can better understand chemistry material. Modules are one of the learning media that can be used as a medium to convey information in the chemistry learning process.

In line with the development of science and technology in an increasingly advanced direction, learning can be carried out in an interesting way by utilizing technology. If students are given interesting learning, it can attract attention and motivate them to learn chemistry, especially molecular material (Hidayah & Destari, 2019). Developments in science and technology can make learning more interactive, for example by moving from printed modules to electronic-based modules or E-modules.

E-Modules or Electronic Modules are modules in digital format consisting of text, images, or both that contain digital electronic material with simulations that can be used for learning. Interactive e-modules can increase student learning interest so that student learning outcomes also increase (Herawati & Muhtadi, 2018). Learning by using e-modules will make learning more efficient, effective, and relevant. The advantage of the electronic module over the printed module is that it is interactive, easy to navigate, can display/read images, sounds, videos and animations and comes with a formative test that provides direct and automatic feedback (Suarsana & Mahayukti, 2013).

Due to the above background, it is expected that the electronic module of molecular materials can improve students' visuospatial intelligence and become a solution that can overcome the difficulties encountered in learning chemical materials. The goal of this study to see if interactive e-module learning media could help students improve their visual-spatial intelligence in molecular shape material. research is limited to obtain the feasibility of interactive electronic modules based on the validity of interactive e-modules on molecular shape material.

## ▪ METHOD

In this study, we used the type of research and development and the ADDIE development model, which consists of five phases: analysis, design, development, implementation, and evaluation (Branch, 2009). This research method is used to develop and validate products so that they can be used in educational settings. Different types of product development can be carried out using the ADDIE model, which includes models, learning strategies, training methods, education media and teaching materials (Puspasari, 2019).

This research begins with the analysis phase to determine the needs and problems encountered in the learning process including performance analysis, analysis of student characteristics, material analysis, and formulation of learning objectives. The second stage is the design phase, which includes the steps of media selection, format decision, learning activity design, and assessment tools. At this stage the design of the research instrument was also carried out, namely the validation sheet. Data from interactive e-module validation results were analysed using a quantitative descriptive method to describe and explain the validation results from interactive e-module development in the form of a percentage score on the media validity assessment sheet. This data is determined based on the Likert scale in the table below.

**Table 1.** Likert Scale Validation

| Scale | Category |
|---|---|
| 1 | Not very good |
| 2 | Not good |
| 3 | Enough |
| 4 | Good |
| 5 | Very Good |

(Riduwan, 2016)

The analytical method in this study uses quantitative descriptive analysis. The expert validation score data is calculated and converted into a percentage by comparing the results of the data scores of all validators with the criterion scores, then measured by category because it contains interval data. The formula used to convert to percent is as follows.

$$P(\%) = \frac{\Sigma\ score\ that\ obtained}{criteria\ score} \times 100$$

With:
P = Validation Percentage
Criteria Score = *maximum score* × *total aspect* × *total respondent*

The result of the calculation is in the form of a percentage which is used to determine the validity of the developed media. The data obtained is then interpreted on a percent scale as shown in Table 2 below.

**Table 2.** Criteria for Interpretation of Validity Scores

| Percentage(%) | Category |
|---|---|
| **0-20** | Very Invalid |
| **21-40** | Less valid |
| **41-60** | Quite valid |
| **61-80** | Valid |
| **81-100** | Very Valid |

(Riduwan, 2016)

Based on the validity criteria above, the learning media developed is said to be valid if the validator's assessment results are ≥ 61% (Riduwan, 2016)

## ▪ RESULT AND DISCUSSION

In the analyse stage, performance analysis is performed to find out the basic problems and needs in learning. The results of teacher interviews showed that students had difficulty identifying PEB and PEI on the central tom, difficulty interpreting the molecular type of formula for molecular shape, difficulty visualizing the shape of the molecule in real terms, and lack of understanding of the effect of PEB repulsion on the shape and angle of the molecule. This is supported by a survey of 32 students who said that matter in molecular form is abstract and that molecular forms are difficult to visualize in 3D. The results of the analysis of student characteristics are used to see differences in the ability levels of students and as material in the development of interactive electronic modules for molecular shape material. Student characteristics can be seen from the level of academic development and the level of mental development of students. At this age, students' mental and cognitive development enters the formal operational stage based on Piaget's theory where this stage has characteristics of abstract and symbolic ways of thinking. This abstract way of thinking can be used to understand chemical materials that have these characteristics in common. However, it is quite complicated for students to solve these abstract problems, so it is necessary to increase visual-spatial intelligence which can be done by visualizing an object that supports students to visualize abstract objects.

The design stage consists of four main steps, namely designing test sheets, selecting media, determining the media format to be used, and the initial design of the media to be developed. The preparation of learning media begins with making the components of the media to be developed, designing two-dimensional images, making illustrations, making three-dimensional models through video illustrations, and compiling storyboards. Students' understanding of chemical representations can be improved by choosing media that can describe a model in a real way. The media chosen is interactive e-module, where this interactive e-module can combine and contain audio, visual, and audio-visual so that students can achieve learning objectives.

At the design stage, the design is carried out by creating a storyboard for the e-module that will be developed. The storyboard that has been made is used as a reference in making interactive e-modules on molecular shape material. The software used to develop interactive e-modules is Microsoft-Word 2019, Adobe Photoshop CS6, Chemdraw Professional 15.0., and FlipPdf Professional 8.0.

The development stage is the stage for developing the initial design of interactive e-module media on molecular shape material that has been made at the design stage. The development stage aims to create and produce interactive e-module products. Activities carried out in the form of expert assessment of the media that has been developed so that suggestions and input are obtained for media improvement or revision.At the development stage, an interactive e-module draft is produced in the .word format, then converted into PDF format. This draft is then edited with FlipPdf Professional 8.0 to add existing features, such as animation, flash, audio, links, and video. The edited draft is then published in the .exe format shown in Figure 1.

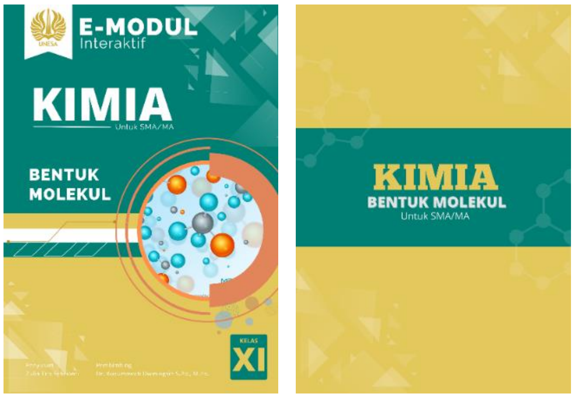
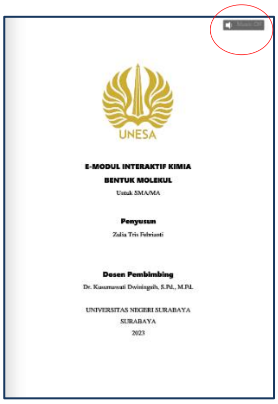
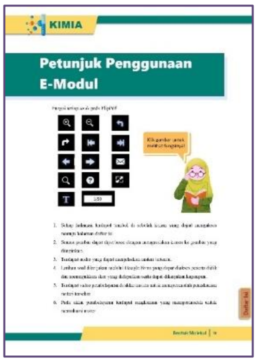
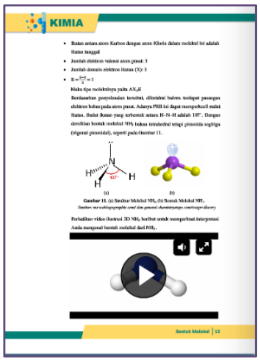
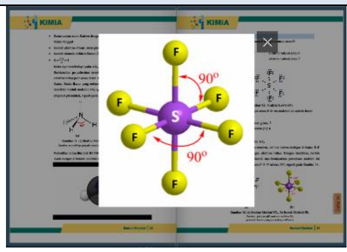
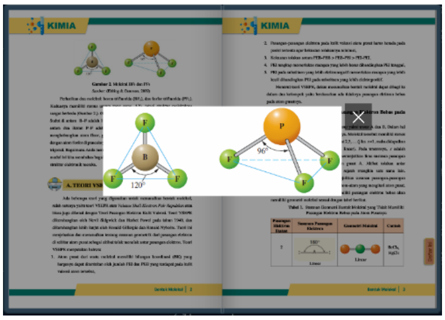
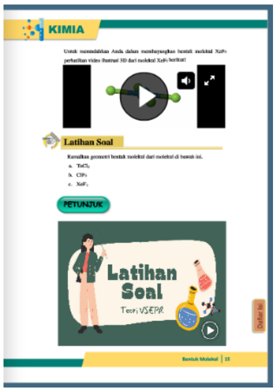
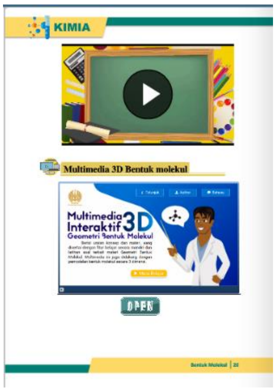



**Figure 1.** Display of the front and back covers of interactive e-modules.

Prepared interactive E modules create draft I. Draft I will be reviewed by a Chemistry Instructor to receive input and suggestions to help revise the Interactive E-Module. Then, based on the validator's suggestions and inputs, we modify the Young's modulus to Draft II. The modified interactive factor results are shown in Table 3 below.

**Table 3.** Revision table of media review result

| No | Suggestions | Revised Result |
|---|---|---|
| 1 | Need to add audio, such as welcome audio. |  |
| 2 | The instructions for use are not informative enough, so more information needs to be added to make it clearer. |  |
| 3 | To make it easier for students to understand the concept map, audio explanations can be added. |  |
| 4 | You can add picture illustrations and videos of molecular shapes to make it easier for students to visualise molecular shapes. |  |

| No | Suggestions | Revised Result |
|---|---|---|
| | | <br> |
| 5 | The e-module component is added with flash and 3D interactive multimedia to make it more interactive. | <br> |

At the development stage, data analysis activities are also carried out which aim to determine the level of validity of interactive e-modules on molecular shape material. The feasibility of a learning media can be reviewed based on three criteria, namely validity, practicality, and effectiveness (Nieveen, 1999). At this stage the aspects of validity will be explained based on the assessment of experts. The validation stage is an assessment of interactive e-modules assessed by 3 validators consisting of two chemistry lecturers and one chemistry teacher.

The expert assessment consists of two processes that must be carried out, namely media review and validation. The review process needs to be carried out before validation is carried out to obtain comments and suggestions from experts which will be made as a reference in the process of improving the initial design of interactive e-module media. After the revision was carried out, it was followed by a validation process by experts using a validation sheet. The following results from the interactive e-module validation in terms of content validity and construct validity are presented in Table 4.

**Table 4.** Table of percentage of content validity and construct validity

| Validity | Persentase (%) | kategori |
|---|---|---|
| Content | 85% | Very Valid |
| Construct | 90% | Very Valid |

Based on the table above, it can be seen that the validity of the interactive e-module obtained a percentage score of 85% on content validity and a percentage of 90% obtained on construct validity. So it can be concluded that the interactive e-module of chemistry molecular shape material is valid to be used as learning media with a score ≥ 61% in each aspect and the suitability of the material with the competency standards and basic competencies (Herawati & Muhtadi, 2018).

**a. Content Validity**

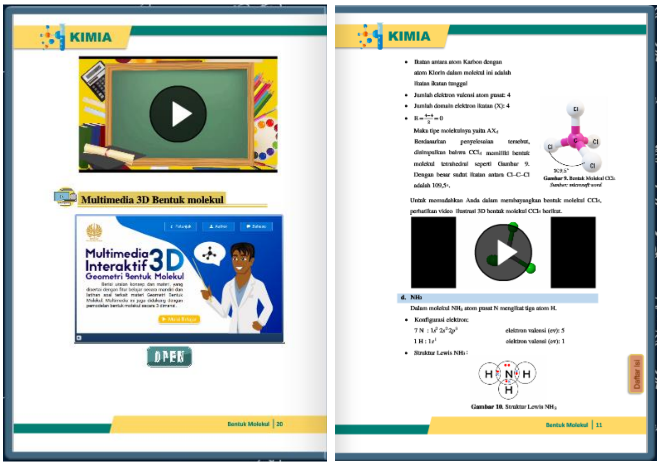
Content validity is a criterion relating to the relevance of material to national standards. The content validity of this interactive e-module is viewed from two aspects, namely content standards and content systematics related to suitability with visual-spatial aspects. Aspects of content standards are criteria related to the suitability of interactive e-module materials with core competencies and basic competencies, and materials that are relevant to learning objectives. This criterion can be assessed from several aspects such as the clarity and relevance of the material, the scope of learning objectives and the depth of the material, the completeness of the e-module, the provision of learning motivation and feedback, and the evaluation (Wahono, 2006). The results of the validation of the contents of interactive e-module can be seen in Table 5 below.

**Table 5.** Table of Percentage of content validity

| Validity | Percentage (%) | Criteria |
|---|---|---|
| Content | 86,67 | Very Valid |
| visual-spatial | 86,67 | Very Valid |

Based on the table, it shows that the content validity criteria which contain the relevance of basic competencies, learning objectives, material, depth of content, and evaluation obtain a validity percentage of 86.67% with a very valid category so that it can be concluded that the content aspects of the interactive e-module are appropriate. In the visual spatial aspect of this interactive e-module, it gets 86.67% with a very valid category. The visual-spatial aspect is a criterion related to the suitability of the interactive e-module material with the relevance between the e- module components and indicators of visual-spatial intelligence. Visual-spatial aspects include illustrations, videos, flash, and multimedia that support the achievement of spatial visual indicators in the visualization of molecular shapes in 3D.

**Table 6.** Component of visual-spatial




**b. Construct Validity**

Construct validity is a criterion related to the consistency of the material with the delivery method. This consistency includes criteria for instructional aspects related to the ease of operating interactive e-modules, language aspects, and presentation aspects. The components of construct validity assessed on interactive e-modules include suitability of interactive e-modules with instructional criteria, suitability of interactive e-modules with linguistic criteria, and suitability of interactive e-modules with presentation criteria. The percentages obtained from construct validation are presented as in Table 6 below.

**Table 7.** Table of percentage of construct validity

| Validity aspect | Percentage (%) | Criteria |
|---|---|---|
| Instructional | 100 | Very Valid |
| Language | 86,67 | Very Valid |
| Presentation | 93,33 | Very Valid |

The instructional aspect of construct validity is a criterion related to the ease of installation and operation of interactive e-modules by users. This aspect can be reviewed based on the instructions for use, ease of operation of the buttons, and ease in guiding students in self-learning activities.

The linguistic aspect of construct validity is a criterion related to the use of language in interactive e-modules. Assessment of linguistic aspects includes the use of correct grammar and spelling based on Indonesian language rules, the language used is easy to understand, coherent between paragraphs, use of punctuation according to EYD, and using appropriate chemical symbols.

The presentation aspect of construct validity is a criterion related to the suitability of interactive e-modules with presentation. This aspect includes the suitability of the cover, design, and completeness of the interactive e-module components. Presentation aspects include interactive e-modules that are developed to have consistent layout proportions (layout of text and images).

Based on Table 7, it shows that there are three aspects of construct validity including the instructional aspect which gets the highest percentage of 100%, the language aspect which gets the percentage of 86.67%, and the presentation aspect which gets the percentage of 93.33%. Based on these data it can be concluded that the chemical interactive e-module on molecular shape material is valid to use as a learning medium with a percentage score of ≥ 61% with a very valid category.

## ▪ CONCLUSION

Based on the analysis of validation data, the conclusion that can be obtained is that this interactive e-module is suitable for use as a learning media that can improve visual spatial intelligence on molecular shape material in terms of content and construct validity with a percentage of 85% and 90% with a very valid category. In addition, this e-module will make it easier for students to visualise real molecular shapes and can increase the effectiveness of chemistry learning. The next activity that needs to be done is to apply interactive e-module learning media in the classroom to determine the effectiveness of interactive e-modules in improving students' visual-spatial intelligence.

## ▪ REFERENCES

Achuthan, K., & Kolil, V. K. (2018). *Using virtual laboratories in chemistry classrooms as interactive tools towards modifying alternate conceptions in molecular symmetry*. https://doi.org/10.1007/s10639-018-9727-1

Ainyn, Q., & Dwiningsih, K. (2021). Multimedia Interaktif dengan Penstimulasian Intelegensi Visual Spasial pada submateri Ikatan Kovalen. *JRPK: Jurnal Riset Pendidikan Kimia*, *10*(2), 132–138. https://doi.org/10.21009/jrpk.102.09

Asri, A. S. T., & Dwiningsih, K. (2022). Validitas E-Modul Interaktif sebagai Media Pembelajaran untuk Melatih Kecerdasan Visual Spasial pada Materi Ikatan Kovalen. *Journal of Science Education*, *6*(2), 465–473.

Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. Springer Science+Business Media.

Enero Upahi, J., & Ramnarain, U. (2019). Representations of Chemical Phenomena in Secondary School Chemistry. *Chemistry Education Research and Practice*, *20*, 146–159. https://doi.org/10.1039/C8RP00191J

Erlina, Enawaty, E., & Rasmawan, R. (2021). Using Simple Molecular Model to Enhance Students' Understanding on Molecular Geometry Based on VSEPR Theory. *Pendidikan Dan Pembelajaran Kimia*, *2*(2 (2021)), 127–143. https://doi.org/10.23960/jppk.v10.i1.April2021.04

Farida, I., Helsy, I., Fitriani, I., & Ramdhani, M. A. (2018). Learning Material of Chemistry in High School Using Multiple Representations. *Materials Science and Engineering*.

González Campos, J. S., Sánchez-Navarro, J., & Arnedo-Moreno, J. (2019). An empirical study of the effect that a computer graphics course has on visual-spatial abilities. *International Journal of Educational Technology in Higher Education*, *16*(1). https://doi.org/10.1186/s41239-019-0169-7

Herawati, N. S., & Muhtadi, A. (2018). Developing Interactive Chemistry E-Modul For The Second Grade Students of Senior High School. *Jurnal Inovasi Teknologi Pendidikan*, *5*(2), 180–191.

Hidayah, R., & Destari, T. Y. (2019). *The Practicality of Scrap-mod as a Learning Media* *on Molecular Geometry*. *95*(Miseic), 222–226.

Marnoufi, K., Ghazlane, I., Soubhi, F. Z., Touri, B., & Aamro, E. (2022). *Effect of Visuospatial Ability on E-learning for Pupils of Physics Option in Scientific Common Trunk*. *13*(11), 192–196.

Nieveen, N. (1999). Prototyping to Reach Product Quality. *Prototyping to Reach Product Quality*, 125–135. https://doi.org/10.1007/978-94-011-4255-7_10

Nurkholik, M. (2021). The Effectiveness of Distance Learning Media Based on Augmented Reality Technology on Covalent Bonding Material for Class X at SMAN 1 Dawarblandong. *Pendidikan Dan Pembelajaran Kimia*, *2*(2 (2021)), 127–143. https://doi.org/10.23960/jppk.v10.i1.2021.03

Nurviandy, I., Dwiningsih, K., Habibi, A. R., & Akbar, A. F. (2020). *Validity of Interactive Multimedia with 3D Visualization to Practice the Spatial Visual Intelligence of Class X High School Students on Metallic Bonding Materials*. *1*(Snk), 140–144. https://doi.org/10.2991/snk-19.2019.33

Puspasari, R. (2019). Pengembangan Buku Ajar Kompilasi Teori Graf dengan Model Addie. *Journal of Medives : Journal of Mathematics Education IKIP Veteran Semarang*, *3*(1), 137. https://doi.org/10.31331/medivesveteran.v3i1.702

Rahmawati, Y., Dianhar, H., & Arifin, F. (2021). Analysing students' spatial abilities in chemistry learning using 3d virtual representation. *Education Sciences*, *11*(4). https://doi.org/10.3390/educsci11040185

Riduwan. (2016). *Skala Pengukuran Variabel-Variabel Penulisan*. Alfabeta.

Saskia, L. A., & Arief, M. (2020). Pengembangan Media Pembelajaran Interaktif Berbasis Android untuk Meningkatkan Hasil Belajar. In *Prosiding Seminar Nasional Ilmu Manajemen 2020 Universitas Negeri Malang*.

Suarsana, I. M., & Mahayukti, G. A. (2013). Pengembangan E-Modul Berorientasi Pemecahan Masalah Untuk Meningkatkan Keterampilan Berpikir Kritis Mahasiswa. *Jurnal Nasional Pendidikan Teknik Informatika (JANAPATI)*, *2*(3), 193. https://doi.org/10.23887/janapati.v2i3.9800

Sukmawati, W. (2019). *Analisis level makroskopis , mikroskopis dan simbolik mahasiswa dalam memahami elektrokimia Analysis of macroscopic , microscopic and symbolic levels of students in understanding electrochemistry*. *5*(2), 195–204.

Sunyono, S., & Meristin, A. (2018). The effect of multiple representation-based learning (MRL) to increase students' understanding of chemical bonding concepts. *Jurnal Pendidikan IPA Indonesia*, *7*(4), 399–406. https://doi.org/10.15294/jpii.v7i4.16219

Tamami, A. A., & Dwiningsih, K. (2020). 3-Dimensions of Interactive Multimedia Validity to Increase Visual-Spatial Intelligence in Molecular Geometry. *Kependidikan*, *4*(2), 241–255.