Investigación educativa

Educación Química

Multiple representation-based mobile apps with learning cycle 7e model on colligative properties of solutions

Múltiples aplicaciones móviles basadas en representaciones con modelo de ciclo de aprendizaje 7e sobre propiedades coligativas de soluciones

Hayuni Retno Widarti[1], Deni Ainur Rokhim and Nuril Maqfiroh Sarosah Rahmaniyah

Recepción: 07/09/21. Aceptación: 01/04/22

Resumen

Los fenómenos químicos se pueden explicar utilizando niveles de representación que consisten en representaciones macroscópicas, submicroscópicas y simbólicas. La explicación de los niveles de representación o conocidas como representaciones múltiples en el aprendizaje de la química es muy importante para proporcionar a los estudiantes una comprensión completa del concepto de material que se estudia. Uno de los temas de la química que requiere múltiples explicaciones de representación son las propiedades coligativas de las soluciones. La investigación tiene como objetivo desarrollar materiales didácticos de aplicaciones móviles basados en representación múltiple con modelo de ciclo de aprendizaje 7e sobre las propiedades materiales coligativas de soluciones que es factible como recurso material. Investigación que se lleva a cabo el desarrollo de la investigación utilizando el modelo 4D Thiagarajan, pero la investigación se limita solo a tres etapas, a saber, las etapas de definición, diseño y desarrollo, y luego continúa con la revisión del producto final de los materiales didácticos. La prueba de validación de materiales didácticos fue realizada por 2 profesores de química y 1 profesor de química. Los aspectos de la validación incluyen la evaluación de aspectos del contenido, la construcción, el idioma, los medios y la conformidad con la sintaxis del ciclo de aprendizaje 7e. La prueba de legibilidad fue realizada por 20 estudiantes de la clase XII IPA SMA Negeri 1 Tumpang. Los aspectos de la prueba de legibilidad incluyen la evaluación de la apariencia, el material de presentación y los beneficios. Los datos obtenidos fueron analizados por porcentaje e interpretados para determinar la factibilidad del material didáctico desarrollado. Los resultados de la prueba de validación obtuvieron un porcentaje del 84% (muy factible) y una prueba de legibilidad del 92% (muy factible). Esto muestra que los materiales didácticos de múltiples aplicaciones móviles basadas en representaciones con el modelo de ciclo de aprendizaje 7e sobre las propiedades coligativas de las soluciones que se han desarrollado son muy factibles para ser utilizados como materiales didácticos.

Palabras clave

Materiales didácticos, Aplicaciones móviles, Representación múltiple, Ciclo de aprendizaje 7E, Propiedades coligativas de las soluciones.

Abstract

Chemical phenomena can be explained using levels of representation consisting of macroscopic, submicroscopic, and symbolic representations. Explanation of representation levels or known as multiple representations in chemistry learning is very important to provide students with a complete understanding of the material concept being studied. One of the chemistry subject matters that requires multiple representation explanations is the colligative properties of solutions. The research aims to develop teaching materials of mobile apps based on multiple representation with learning cycle 7e model on the material colligative properties of solutions which is feasible as a material resource. Research which is conducted the research development by using the 4D model Thiagarajan, but research is limited only in three stages namely the define, design, and develop stages, then continued with the revision of the final product of teaching materials. The validation test of teaching materials was carried out by 2 chemistry lecturers and 1 chemistry teacher. Aspects of validation include assessing aspects of content, construct, language, media, and conformity with the learning cycle 7e syntax. The readability test was carried out by 20 students of XII class IPA SMA Negeri 1 Tumpang. Aspects of readability test include assessment of appearance, presentation material, and benefits. The data obtained were analyzed by percentage and interpreted to determine the feasibility of developed teaching material. The results of the validation test obtained a percentage of 84% (very feasible) and a readability test of 92% (very feasible). This shows that the multiple representation-based mobile apps teaching materials with the 7e learning cycle model on the colligative properties of the solutions that have been developed are very feasible to be used as teaching materials.

Keywords

Teaching Materials, Mobile Apps, Multiple representation, Learning Cycle 7E, Colligative Properties of Solutions.

[1] Universitas Negeri Malang, Indonesia.

Cómo citar: Retno Widarti, H., Ainur Rokhim, D. and Sarosah Rahmaniyah, N. M.(2022, julio-septiembre). Multiple representation-based mobile apps with learning cycle 7e model on colligative properties of solutions. *Educación Química, 33*(3). http://dx.doi.org/10.22201/fq.18708404e.2022.3.80540

Introduction

Education in the 21st century requires modern and professional education management with nuances of technology (Nurchaili, 2010). The more rapid the development of technology, the more educational technology teachers are starting to introduce in the classroom (Ling et al., 2014). This is because technology-assisted learning tools can facilitate broad learning activities by actively involving students in learning activities (Evans & Gibbons, 2007). One of the technologies that are starting to be used in the classroom is the use of mobile devices or commonly known as mobile phones. Compared to technology that is starting to be considered traditional such as computers, mobile devices are considered more efficient because they can be carried anywhere and with the help of the internet students can learn anywhere (Ling et al., 2014). Mobile devices also encourage mobile-learning, where mobile-learning is what drives the development of an application called mobile application or commonly abbreviated as mobile-apps as a technology to support the teaching and learning process (Luna-Nevarez & McGovern, 2018).

One of the sciences that is closely related to technology is chemistry. Chemistry is a science that studies matter and the changes that occur in that material (Burdge & Overby, 2017). Learning chemistry is basically learning about most concepts that are abstract and require understanding in molecular terms or commonly referred to as submicroscopic (Sunyono, 2012). As it is known that chemistry consists of 3 levels of representation, namely macroscopic, submicroscopic, and symbolic. The macroscopic level is a chemical phenomenon that can be observed using the five senses and can include experiences from everyday life. The submicroscopic level represents something that is real but too small to be seen, such as electrons, molecules, and atoms. The symbolic level includes the use of chemical equations, graphs, pictures, algebra, etc. (Treagust et al., 2003). Multiple representation is an important component in chemistry learning considering the concept of chemistry is very abstract, so the presence of multiple representations can provide a deeper understanding (Autores, 2021). One of the chemistry subject matters that requires multiple representation explanations is the colligative properties of solutions.

So far, chemistry learning (including the colligative properties of solutions) tends to only focus on the macroscopic and symbolic levels (Indrayani, 2013). The widely circulated teaching materials for chemistry subjects still do not include multiple representation chemistry in its entirety, especially for the colligative properties of solutions. The results of the analysis in the book entitled Active Learning Chemistry for SMA and MA Class XII by Elisabeth, et al give the results that in the colligative properties of the solution a multiple representation explanation is presented for the decrease in vapor pressure and osmotic pressure, while the boiling point elevation and freezing point depression are only presented with level explanations. macroscopic and symbolic only. Therefore, it is necessary to develop teaching materials that include three levels of complete representation so that students can understand chemistry, especially the colligative properties of solutions.

One form of teaching materials that has begun to be widely developed is teaching materials in the form of applications or mobile apps. This is because the use of mobile apps in learning activities is increasingly being used (Farrah & Abu-Dawood, 2018). Research conducted by Ahmar & Rahman (2017) shows the benefits of teaching materials in the

Educación Química
Volumen 33 | Número 3 | Páginas 115-126 | julio-septiembre 2022
http://dx.doi.org/10.22201/fq.18708404e.2022.3.80254

form of applications in learning activities, with the result that 90% of students say they understand the material and practice questions faster when using android applications as teaching materials (76% strongly agree and 24% agree) and 100% of students feel more ready to accept the material to be taught. The development of teaching materials in the form of applications can also be developed for chemistry. In learning chemistry, especially the colligative properties of solutions where most of the concepts are abstract, the use of mobile apps can be one way to show submicroscopic representations that can be presented in the form of images or videos in the mobile apps themselves.

The presentation of the material in the mobile apps teaching materials developed in the research is presented with the syntax of the 7E learning cycle learning model or known as LC 7E. The LC 7E learning model involves students actively through 7 stages in learning, namely: Elicit, Engage, Explore, Explain, Elaborate, Evaluate, and Extend. In general, the LC 7E learning model is intended for learning with a constructivist approach to science learning where students use their experiences in everyday life and prior knowledge to understand a concept (Saraç & Şekerci, 2018). Based on the various considerations that have been described, the research carried out aims to develop multiple representation-based mobile apps teaching materials with a learning cycle 7e learning model on the colligative properties of solutions and determine their feasibility to produce teaching materials that can visualize three levels of representation for material colligative properties of solutions. .

Literature review

Chemical Representation

Chemical representations consist of macroscopic, submicroscopic, and symbolic representations. The macroscopic level is a chemical phenomenon that can be observed using the five senses. The results of observations can be in the form of odors, deposits, color changes, and gas formation in chemical reactions (Indrayani, 2013). The macroscopic level can be observed both through experimental activities in the laboratory and experiences in everyday life and therefore can be measured. Examples of measurements that can be observed at the macroscopic level are mass, density, concentration, pH, temperature, and osmotic pressure (Gilbert & Treagust, 2009).

The next level is the submicroscopic level which represents something real but too small to be observed (Treagust et al., 2003). The submicroscopic level provides an explanation at the particulate level where matter is described as consisting of atoms, molecules, and ions. The symbolic level includes the use of chemical symbols, formulas and equations, pictures of molecular structures, and diagrams (Chandrasegaran et al., 2007). The symbolic level is also the use of subscripts to indicate the number of atoms in a molecule, letters that indicate the phase such as solid (s), liquid (l), gas (g), and solution (aq), the use of coefficients in reaction equations, etc. (Gilbert & Treagust, 2009).

Teaching materials

According to Maskur et al., (2019) teaching materials are learning materials that are deliberately arranged and utilized by teachers in learning interaction. Suprawoto (2009)

Educación Química
Volumen 33 | Número 3 | Páginas 115-126 | julio-septiembre 2022
http://dx.doi.org/10.22201/fq.18708404e.2022.3.80254

provides several definitions of teaching materials including: (a) teaching materials are all types of materials that can be used by teachers in carrying out learning activities in the classroom, (b) teaching materials are devices or texts needed by teachers in planning and studying implementation of teaching and learning, and (c) teaching materials are a collection of materials that have been arranged as efficiently as possible to create an environment and learning atmosphere for students. Based on the definitions mentioned, it can be concluded that teaching materials are a collection of materials, both written and unwritten, which are arranged systematically and used in learning activities.

Teaching materials have an important role for both teachers and students. For teachers, the existence of teaching materials can save learning time. This is because the teacher can ask students to read the material before the lesson begins. Teaching materials can also change the role of the teacher from a teacher to a facilitator. The existence of teaching materials can improve the learning process to be more effective and interactive. The role of teaching materials for students includes helping students to learn independently before lessons begin and providing opportunities for students to learn anytime and anywhere (Sadjati, 2017).

Mobile Application

Mobile apps or mobile applications are software applications that run on mobile devices such as Android or tablets (Ling et al., 2014). Mobile apps are the latest form of technology-assisted learning tools that are being developed a lot. With the benefits of technology seen in providing a learning experience for students, the urge to use technology is increasing so that the development of mobile apps is needed as teaching materials. In chemistry learning where most of the concepts are abstract, the use of mobile apps can be used as a way of showing submicroscopic representations that can be presented in the form of images or videos in the mobile apps themselves.

The development of mobile apps as teaching materials for colligative properties of solutions in this study is based on the content of the material. The material is presented with the syntax of the 7E learning cycle learning model. In the teacher's teaching materials, lesson plans are presented as learning guidelines using mobile apps teaching materials. The learning steps in the RPP consist of 4 meetings each for sub-discussions of vapor pressure reduction, boiling point elevation, freezing point depression, and osmotic pressure.

Learning Cycle 7E. Learning Model

The 7E learning cycle learning model was developed from the 5E learning cycle learning model by expanding the engage stage to elicit and engage stages and elaborate and evaluate stages to elaborate, evaluate, and extend. The purpose of the 7E learning cycle learning model is to emphasize the importance of students' prior knowledge as well as the expansion of concepts (Eisenkraft, 2003). The 7E learning cycle learning model consists of 7 stages, each of which is described in Table 1.

Stages	Activities in Mobile Apps Teaching Materials
Elicit The elicit stage aims to elicit students' initial understanding and ascertain what students know before the lesson begins (Eisenkraft, 2003).	At the elicit stage, instructions are presented in mobile apps teaching materials that ask students to provide examples of the application of colligative properties of solutions that students have encountered in everyday life.
Engage The engage stage aims to attract students' attention, make students think about the material to be studied, raise questions in students' minds, stimulate students to think, and access prior knowledge (Eisenkraft, 2003).	At the engage stage, images are presented in mobile apps teaching materials as well as several related questions to make students think and be interested in the colligative properties of the solution to be studied.
Explore The explore stage provides opportunities for students to observe, record data, isolate variables, design and plan experiments, create graphs, interpret results, develop hypotheses, and organize their findings (Eisenkraft, 2003).	At the explore stage, a discussion sheet is presented which students must discuss in groups. The discussion sheet consists of sub-discussions of vapor pressure drop, boiling point elevation, freezing point depression, and osmotic pressure. Besides being presented with discussion sheets, at the explore stage, material on colligative properties of solutions is also presented.
Explain At the explain stage the teacher introduces students to scientific vocabulary and provides questions that help students use scientific vocabulary to explain the findings at the explore stage (Eisenkraft, 2003).	In the explain stage, a submicroscopic video is presented of the decrease in vapor pressure, boiling point elevation, freezing point depression, and osmotic pressure.
Elaborate The elaborate stage provides opportunities for students to apply their knowledge to new concepts, including asking new questions and hypotheses to explore (Eisenkraft, 2003).	At the elaborate stage, data on colligative properties of electrolyte and nonelectrolyte solutions are presented as well as some questions. At the elaborate stage also presented a discussion of the colligative properties of electrolyte solutions.
Evaluate At the evaluate stage the teacher assesses students' understanding in accordance with the learning activities carried out (Eisenkraft, 2003)	At the evaluate stage, evaluation questions are presented, both multiple choice and a description of the colligative properties of the solution.
Extend At the extend stage the teacher needs to ensure that the knowledge gained by students is applied in a new context (Eisenkraft, 2003)	In the extend stage, the application of colligative properties of solutions in everyday life is presented.

TABLE 1. Stages of Learning Cycle 7E and Activities in Mobile Apps Teaching Materials.

Material Characteristics Colligative Properties Solution

Colligative properties of solutions are one of the materials taught in Class XII IPA SMA Semester 1. Colligative properties of solutions are properties of solutions that only depend on the amount of solute and do not depend on the type of solute. The colligative properties of a solution consist of a decrease in vapor pressure, elevation in boiling point, depression in freezing point, and osmotic pressure. Colligative properties of solutions are materials that require understanding at all levels of representation. The sub-discussion of colligative properties of solutions on mobile apps teaching materials is presented in Table 2.

Sub-Discussion	Representation
• Vapor Pressure Drop • Boiling Point Elevation • Freezing Point Depression • Osmotic Pressure	Macroscopic: • Application of colligative properties of solutions in daily life • Data colligative properties of solutions
	Submicroscopic: • Explanation of the particulate level of colligative properties of the solution which can be supplemented by submicroscopic pictures or videos
	Symbolic: • P-T diagrams, formulas and chemical equations in the material colligative properties of solutions

Table 2. Sub-Discussion and Representation in Material Colligative Properties of Solutions.

Research methods

The research conducted is research on the development of teaching materials. The development is carried out using a 4D model developed by Thiagarajan et al., (1974) which consists of four stages, namely define, design, develop, and disseminate. The disseminate stage was not carried out due to time and cost constraints, so the research was carried out until the third stage, namely developing, and then continuing with the revision of the final product. The research subjects consisted of expert validators as competent people in the field of developing teaching materials and colligative properties of solutions (two chemistry lecturers and one chemistry teacher) and 20 students of class XII science at SMA Negeri 1 Tumpang for the readability test.

The types of data collected in the study consisted of qualitative data and quantitative data. Qualitative data is data in the form of sentences, words, and pictures (Sugiyono, 2016). The qualitative data in this study was obtained from the suggestions and responses of each validator which was then used as the basis for product improvement. Apart from the validator, qualitative data was also obtained from the suggestions and responses of students on the product readability test questionnaire. Quantitative data is data in the form of numbers and qualitative data that are scored (Scoring) (Sugiyono, 2016). Quantitative data were obtained from the results of expert validation and readability tests measured by a Likert Scale with values of 5,4,3,2, and 1. Quantitative data were analyzed in percentage terms to determine the feasibility of the teaching materials that had been developed.

Volumen 33 | Número 3 | Páginas 115-126 | julio-septiembre 2022
http://dx.doi.org/10.22201/fq.18708404e.2022.3.80254

The data collection instruments in the study were in the form of a validation test questionnaire (content aspects, constructs, language feasibility, media, and conformity with LC 7E syntax) and readability test questionnaires (display aspects, material presentation, and benefits). The percentage of assessment obtained is based on a Likert Scale calculation with a description of the scale of "5" being very good, "4" good, "3" quite good, "2" not good, and "1" not good. The data obtained from the validation test and readability test were analyzed using the percentage technique with the following formula

$$P = \frac{X}{Y} \times 100\%$$

P : Percentage of gain

X : Total score of answers

Y : The maximum score of the answer

The results of these calculations are then interpreted as in Table 3.

Table 3. Interpretation of Eligibility Score for Mobile Apps Teaching Materials.

Percentage	Criteria
0% – 20%	Very Not Feasible
21% – 40%	Not Feasible
41% – 60%	Feasible Enough
61% – 80%	Feasible
81% – 100%	Very Feasible

Results and discussion

The teaching materials developed are teaching materials in the form of applications that can be accessed using mobile devices with the Android system. As it is known that mobile devices are technology that can be accessed anytime and anywhere (Ling et al., 2014), with this, teaching materials in the form of applications can also be accessed by students easily. Teaching materials are developed for the colligative properties of solutions and are equipped with multiple representations in chemistry. The material in the teaching materials is presented with the syntax of the LC 7E learning model. The display of teaching materials is presented in Figure 1.

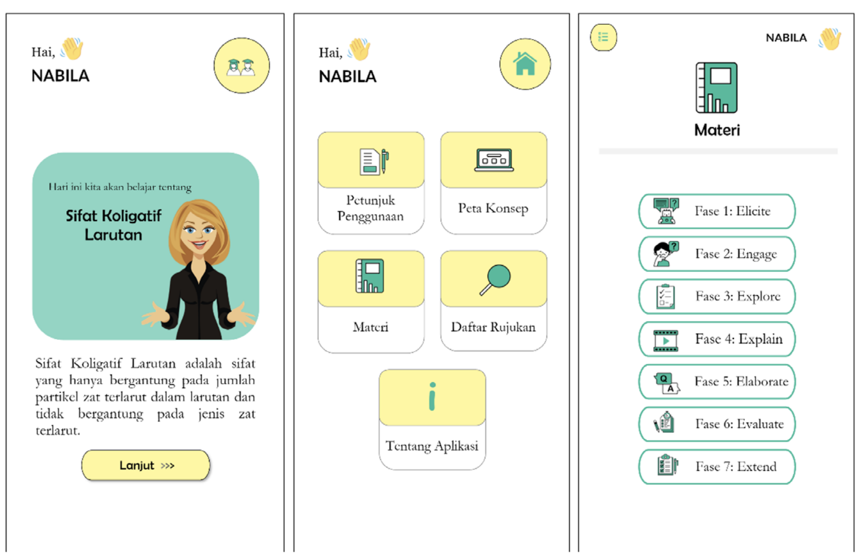

Figure 1. Display of Mobile Apps Teaching Materials.

Educación Química
Volumen 33 | Número 3 | Páginas 115-126 | julio-septiembre 2022
http://dx.doi.org/10.22201/fq.18708404e.2022.3.80254

The process of developing mobile apps teaching materials at the define stage is carried out by conducting a needs analysis so that the objectives and limitations of the developed teaching materials can be described. In the define stage, it is done by analyzing the learning material of colligative properties of the solution, literature review examining KI and KD, literature reviewing analysis of student learning resources, preparing sources of material for developing teaching materials, and formulating indicators of competency achievement. Based on the results of the analysis, it was found that the teaching materials for colligative properties of existing solutions still did not include multiple representations in chemistry completely on all colligative properties.

The second stage, namely the design stage, is carried out by determining the design of the teaching materials developed and developing the initial design of the teaching materials. At the design stage, the content of teaching materials, concept maps, lesson plans, evaluations, and assessment guidelines are also carried out. Core competencies and basic competencies are used as a reference for the preparation of materials in teaching materials. The material is presented using the LC 7E learning model syntax and includes multiple representations in chemistry. The results of the design of teaching materials at the design stage are used as the initial design of teaching materials.

The third stage, namely the develop stage, is carried out by testing the initial design validation of the developed teaching materials. The validation test aims to determine the feasibility of the teaching materials that have been developed (Zakaria et al., 2020) and to obtain suggestions from the validator for the improvement of teaching materials. The results of the validation test by the validator are presented in Table 4. Teaching materials that have been revised based on suggestions from the validator are then tested for readability to 20 students of class XII science. The results of the readability test are presented in Table 5. Both the data from the validation and the readability test were analyzed by percentage and then interpreted as in Table 3 to determine the feasibility of the teaching materials that have been developed.

Table 4. Test Results of Teaching Material Validation by Validator.

No	Rated aspect	Percentage	Criteria
1	Teaching material content	83%	Very Feasible
2	Construction of teaching materials	83%	Very Feasible
3	Language eligibility	84%	Very Feasible
4	Media mobile apps	85%	Very Feasible
5	Compatibility with Learning Cycle 7E syntax	86%	Very Feasible
Average		**84%**	**Very Feasible**

Based on the data in Table 4, the content aspect of teaching materials gets a percentage of 83% so that it is categorized as very feasible in terms of content. This is because the development of teaching materials refers to KI and KD. The suitability of teaching materials with KI and KD is very important considering that they are the basic reference for changing textbooks (Permendikbud, 2016). The feasibility of teaching materials is also supported because of the suitability of sample questions and evaluations with materials

Educación Química
Volumen 33 | Número 3 | Páginas 115-126 | julio-septiembre 2022
http://dx.doi.org/10.22201/fq.18708404e.2022.3.80254

and indicators of competency achievement, this is needed so that the ability of students is in accordance with the demands of basic competencies. The feasibility of the developed teaching materials can also be seen from the complete coverage of the material in the teaching materials, the notations, or symbols in the teaching materials in accordance with the rules of chemical writing, besides that both the material concepts, sample questions, and evaluations are correct theoretically and do not cause many interpretations. Content validity is very important so that the teaching materials developed are scientifically correct and do not spread misconceptions to students (Sadjati, 2017).

The construct aspect of teaching materials is categorized as very feasible with a percentage of 83%. This is supported by the location of the material presented in sequence based on easy material to difficult material. In line with the principle of compiling learning modules expressed by Suprawoto (2009) that material must be arranged from the easiest first to understand the more difficult material. The feasibility of teaching materials in terms of constructs is also supported because of the suitability of the presentation of images and videos with the material presented. This suitability is important so that both pictures and videos in teaching materials can help students better understand the material presented. Chairiah et al., (2016)in their research revealed that the use of video can help improve students' understanding of concepts. The pictures and videos in the teaching materials also show multiple representations for the colligative properties of the solution. This is in line with the results of research by Mekwong & Chamrat, (2021) that learning chemistry must present three levels of representation so that students better understand the concepts being studied. In addition to this, the size and type of letters, as well as the right choice of colors also support the feasibility of teaching materials in terms of constructs.

The aspect of language feasibility is categorized as very feasible with a percentage of 84%. This is because the language used in presenting the material and presenting the questions is adjusted to the official Indonesian spelling, easy to understand, and does not have multiple meanings so as not to confuse students. In line with the research results of Ulfah & Jumaiyah (2018)that the language used in teaching materials must use the right language so that the information presented can be understood well by students. The feasibility aspect of mobile apps media is categorized as very feasible with a percentage of 85%. This is because it is supported by the technical quality of teaching materials. Attractive colour combinations in teaching materials are needed so that students do not feel bored when learning to use the developed teaching materials. The existence of buttons/navigations that are easy to understand and function is very helpful in the use of teaching materials so that teaching materials can be operated easily. The feasibility of teaching materials is also supported by the usefulness of the developed teaching materials. Teaching materials can help students learn, can generate student motivation to learn, can provide positive benefits in learning, and can provide opportunities for students to learn independently. This is in line with Ahmar & Rahman (2017) who in their research revealed that android teaching materials in the form of applications can increase students' motivation to learn.

The aspect of conformity with the 7E learning cycle syntax is categorized as very feasible with a percentage of 86%. This is because the activities, materials, pictures, videos, data, and evaluation questions are presented according to the stages in the syntax of the LC 7E learning model. Overall, the average percentage of teaching material validation

Educación Química
Volumen 33 | Número 3 | Páginas 115-126 | julio-septiembre 2022
http://dx.doi.org/10.22201/fq.18708404e.2022.3.80254

test results is 84%, with this, overall mobile apps teaching materials developed are very feasible to be used in learning activities both in terms of content, constructs, language, media, and conformity with learning syntax. cycle 7E, however, for the improvement of teaching materials, improvements were made according to suggestions and comments from the validator.

In addition to the validation test, this study also conducted a readability test. Based on the data in Table 5, both aspects of appearance, presentation of material, and benefits are categorized as very feasible with percentages of 90%, 92%, and 94%, respectively. Overall, the percentage of the readability test is 92%, which means that the multiple representation-based mobile apps teaching materials developed are very feasible for learning activities.

Table 5. Results of the Readability of Teaching Materials by Students.

No	Rated aspect	Percentage	Criteria
1	Appearance	90%	Very Feasible
2	Material Presentation	92%	Very Feasible
3	Benefit	94%	Very Feasible
	Average	**92%**	**Very Feasible**

Conclusions

Based on the obtained percentage of validation test results of 84% (very feasible) and readability test of 92% (very feasible), it can be concluded that the teaching materials developed are very suitable to be used as teaching materials in learning activities. Teaching materials are very suitable to be used both in terms of content, construct, language, media, as well as conformity with the syntax of the LC 7E learning model. Teaching materials are also very feasible in terms of appearance, presentation of material, and benefits.

Multiple representation-based teaching materials with the LC 7E learning model syntax for material colligative properties of solutions that are loaded in the form of mobile apps is one of the newly developed teaching materials. The research shows that the multiple representation-based mobile apps teaching materials that have been developed are very feasible to use. Therefore, the researcher suggests to other researchers to develop multiple representation-based teaching materials on other chemical materials while still adjusting the characteristics of the material in the Learning Cycle 7E learning model. In addition, because the teaching materials developed in this study can only be used for the android system, the researchers also suggest that further development can be used for iOS (iPhone operating system) as well.

References

Ahmar, A. S., & Rahman, A. (2017). Development of teaching material using an Android. *Global Journal of Engineering Education*, *19*(1), 72–76. https://doi.org/10.26858/gjeev19i1y2017p7376

Burdge, J., & Overby, J. (2017). *Chemistry : atoms first, Third Edition*. McGraw-Hill Education.

Chairiah, Siregar, L. F., & Masyithah, H. (2016). Meningkatkan pemahaman konsep kimia dengan menggunakan media video pembelajaran di smk negeri 1 stabat kelas xi av.2. *Prosiding Seminar Nasional Kimia Dan Pendidikan Kimia*, 256–261.

Chandrasegaran, A. L., Treagust, D. F., & Mocerino, M. (2007). The development of a two-tier multiple-choice diagnostic instrument for evaluating secondary school students' ability to describe and explain chemical reactions using multiple levels of representation. *Chemistry Education Research and Practice*, *8*(3), 293–307. https://doi.org/10.1039/B7RP90006F

Eisenkraft, A. (2003). Expanding The 5E Model. *The Science Teacher*, *70*, 56–59.

Evans, C., & Gibbons, N. J. (2007). The interactivity effect in multimedia learning. *Computers and Education*, *49*(4), 1147–1160. https://doi.org/10.1016/j.compedu.2006.01.008

Farrah, M. A., & Abu-Dawood, A. K. (2018). Using Mobile Phone Applications in Teaching and Learning Process. *International Journal of Research in English Education*, *3*(2), 48–68. https://doi.org/10.29252/ijree.3.2.48

Gilbert, J. K., & Treagust, D. F. (2009). *Introduction: Macro, Submicro and Symbolic Representations and the Relationship Between Them: Key Models in Chemical Education*. 1–8. https://doi.org/10.1007/978-1-4020-8872-8_1

Indrayani, P. (2013). Analisis Pemahaman Makroskopik, Mikroskopik, dan Simbolik Titrasi Asam-Basa Siswa Kelas XI IPA SMA serta Upaya Perbaikannya dengan Pendekatan Mikroskopik. *Jurnal Pendidikan Sains*, *1*(2), 109–120.

Ling, C., Harnish, D., & Shehab, R. (2014). Educational Apps: Using Mobile Applications to Enhance Student Learning of Statistical Concepts. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *24*(5), 532–543. https://doi.org/10.1002/hfm.20550

Luna-Nevarez, C., & McGovern, E. (2018). On the Use of Mobile Apps in Education: The Impact of Digital Magazines on Student Learning. *Journal of Educational Technology Systems*, *47*(1), 17–31. https://doi.org/10.1177/0047239518778514

Maskur, R., Latifah, S., Pricilia, A., Walid, A., & Ravanis, K. (2019). The 7E learning cycle approach to understand thermal phenomena. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 464–474. https://doi.org/10.15294/jpii.v8i4.20425

Mekwong, S., & Chamrat, S. (2021). The Development Learning Activities Using Three Levels of Chemical Representation for Enhance Upper Secondary Students' Organic Chemistry Concepts. *Journal of Physics: Conference Series*, *1835*(1), 0–9. https://doi.org/10.1088/1742-6596/1835/1/012027

Nurchaili. (2010). Pengaruh Media Pembelajaran Berbasis Teknologi Informasi Dalam Proses Pembelajaran Kimia Terhadap Peningkatan Hasil Belajar Siswa. *Jurnal Pendidikan Dan Kebudayaan*, *16*(6), 648. https://doi.org/10.24832/jpnk.v16i6.493

Permendikbud. (2016). *Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 24 Tahun 2016 tentang Kompetensi Inti dan Kompetensi Dasar Pelajaran pada Kurikulum 2013 Pada Pendidikan Dasar dan Pendidikan Menengah*.

Sadjati, I. M. (2017). Modul 1: Hakikat Bahan Ajar. In *Pengembangan Bahan Ajar* (Vol. 3, Issue 1, pp. 1–62). Universitas Terbuka. http://repository.ut.ac.id/4157/1/IDIK4009-M1.pdf

Educación Química
Volumen 33 | Número 3 | Páginas 115-126 | julio-septiembre 2022
http://dx.doi.org/10.22201/fq.18708404e.2022.3.80254

Saraç, H., & Şekerci, A. R. (2018). Evaluation of Multimedia Assisted Applications Designed According to 7e Learning Model on Student Opinions. *Journal of Research in Science Mathematics and Technology Education*, *1*(1), 63–89. https://doi.org/10.31756/jrsmte.114

Sugiyono. (2016). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. ALFABETA.

Sunyono. (2012). Kajian teoritik model pembelajaran kimia berbasis multipel representasi (simayang) dalam membangun model mental pebelajar. *Prosiding Seminar Nasional Sains, Universitas Negeri Surabaya*, 486–495.

Suprawoto, N. A. (2009). Mengembangkan Bahan Ajar dengan Menyusun Modul. *Journal Pendidikan Indonesia*, 1–8.

Thiagarajan, Semmel, S., & Semmel. (1974). *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*.

Treagust, D. F., Chittleborough, G., & Mamiala, T. L. (2003). The role of submicroscopic and symbolic representations in chemical explanations. *International Journal of Science Education*, *25*(11), 1353–1368. https://doi.org/10.1080/0950069032000070306

Ulfah, A., & Jumaiyah. (2018). Jurnal Inovasi Pendidikan pengembangan bahan ajar mata kuliah bahasa indonesia. *Jurnal Inovasi Pendidikan*, *2*(2), 1–9.

Autores (2021).

Zakaria, L. M. A., Purwoko, A. A., & Hadisaputra, S. (2020). Pengembangan Bahan Ajar Kimia Berbasis Masalah Dengan Pendekatan Brain Based Learning: Validitas dan Reliabilitas. *Jurnal Pijar Mipa*, *15*(5), 554. https://doi.org/10.29303/jpm.v15i5.2258