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ANDROID-BASED MOBILE LEARNING APPLICATION DESIGN: ITS IMPLEMENTATION AND EVALUATION FOR AIDING SECONDARY SCHOOL STUDENTS' TO STUDY INORGANIC COMPOUND NOMENCLATURE

C. Kurniawan*[1], M. Dhiyaulkhaq[1], N. Wijayati[1], K. Kasmui[1], D. Nasekhah[2], M. H. Ismail[3]

[1]Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Indonesia
[2]Sekolah Menengah Atas Negeri 7 Semarang, Indonesia
[3]Science Education Department, Faculty of Education, Universiti Teknologi MARA, Puncak Alam Campus, Selangor, Malaysia

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ABSTRACT

Inorganic compound nomenclature is one of the most basic concepts in chemistry. Therefore, for students, correct naming of the chemicals is essential before learning advanced chemistry. However, nomenclature as a learning topic consists of rules and thus requires frequent practice. Tenth graders will face difficulties if they have remember thousands of the chemicals' names. The objective of this research is to develop and validate the effectiveness of android-based learning media to help students in learning chemical compound nomenclature. In order to meet the goal, this study was conducted in stages; they are (1) information collection, (2) planning, (3) product draft development, (4) small-scale trials, (5) product revisions, and (6) large-scale trials. The effectiveness of the examined mobile-app was measured using post-test questions, resulting in 87.88% student completion. Furthermore, since experts have been in agreement concerning the validity of the examined mobile app – both the content and the media, the app can be used for learning process.

Keywords: android; android-based learning media; chemical compound nomenclature; student difficulties

INTRODUCTION

Learning is something that a person does to add insight. In learning, of course, students experience difficulties, and the difficulty level of each subject is different for each student (Lodge et al., 2018). Generation after generation of students has come to enjoy chemistry after overcoming learning "barriers", but some of them fail and quit. Chemistry is one of the subjects considered difficult by students because they have to learn a lot of abstract things, one of which is in the nomenclature of chemicals (Redhana et al., 2017; Treagust et al., 2018; Schlüter et al., 2022).

Students learning inorganic nomenclature and formula are bound to struggle with written language, nomenclature norms, memorization, teacher dependency, and chemical compound representation (Vogel & Houk, 2018). A tool called FORMula has been developed to lessen or eliminate hurdles to learning inorganic chemistry nomenclature (Garrido-Escudero, 2013). Antonio (2012) suggested the use of card games for learning elements and compounds including their nomenclature (Franco Mariscal et al., 2012). This method was recently studied and was found to be

***Correspondence Address**
E-mail: kurniawan.cepi@mail.unnes.ac.id

still effective to overcome student difficulties in learning nomenclature (Wood & Donnelly-Hermosillo, 2019; Buendía-Atencio et al., 2022).

In our preliminary observation at several schools, we found that in 2021 student's achievement (mastery level) in nomenclature topic was about 66%. The fact indicates that student's understanding about this topic needs to be improved. In another published work, in SMAN 1 Sungai Raya, Aceh, Indonesia, student's mastery level in the topic was only 41.83% (Lestari et al., 2021). Lestari et al. (2021) identified that students do not know about stages in writing chemical compounds. In addition, the use unattractive learning media makes students less interested in chemical compound nomenclature.

Another shortcoming in chemistry subjects, particularly in the topic of nomenclature, is the use of un-updated references (textbook and worksheets). Textbooks used in public schools are provided by the government, borrowed by the students from library. Students from later different academic year use the same copy that have been used by their seniors, who sometimes left the answers to the exercise's questions uncleaned. The worksheets, with the presence of digital media, now become less attractive, boring, and unreadable in low-light exposure places (Yang et al., 2016). Thus, learning media that can be combined with technology is then needed.

Mobile learning is one of the alternatives in learning media development; here smartphone devices are utilized. Mobile learning apps are expected to benefit both teachers and students (Ningsih & Adesti, 2020) as students will have the opportunity to learn and study independently and they can be accessed anywhere and anytime (Astuti et al., 2017). Further, Astuti et al. (2017) also mentioned that about 89% of Indonesian people use smartphones. Therefore, developing mobile learning apps to help the students face their difficulties in chemistry is one good effort.

The use of mobile learning apps for studying nomenclature have been reported. One successful gamification of chemical nomenclature, called Molebots, was reported by Gupta (2019). An important finding from the research about Molebots is that it is a computer-based or screen-based application. Its effectiveness was explained using a media-comparison approach (Gupta, 2019). However, mobile app for the nomenclature of inorganic compounds is still rare. Then, the pandemic period has forced innovation in teaching and learning. Students had to be facilitated to promote active learning and self-studying outside classrooms (Feldt et al., 2012; Baldock et al., 2021; Kelley, 2021). Based on the research background, this research was addressed to design an Android-based mobile learning media for teaching inorganic nomenclature and to evaluate its effectiveness in improving student's skill in the topic.

The main purpose of this study is to design and examine the effectiveness of Chemistry Learning App for the tenth grader in the topic of inorganic chemical nomenclature. To be specific, the objectives of this study are (1) to obtain ratings from experts (chemistry, media, and educational technology experts) regarding the developed mobile-app and (2) to examine the effectiveness of the mobile app in helping senior high school students learning about the topic in the app.

METHODS

The population of the research are the 2021-2022 tenth graders of Public High-School 7 of Semarang, Indonesia. Purposive sampling was used to determine the number of samples based on the recommendation from the teachers. This research refers to the R&D method developed by Borg and Gall (Gall et al., 2007). The stages are (1) information collection, (2) planning, (3) product draft development, (4) small-scale trials (10 students from the tenth graders), (5) product revisions, (6) large-scale trials (33 students from the eleventh graders). The stages were conducted to determine the validity and effectiveness of Android-based learning media in helping students to study about the nomenclature of chemical compounds.

First, information collection. This stage was carried out to analyse the needs, to review literature, and to identify the cause of the problem, thus requiring the development of new models (Gall et al., 2007). The need analysis was based on the learning syllabus, which are a reference for the implementation of learning activities. In this case, the syllabus refer to the revised national K-13 curriculum. The analysis was carried out on the syllabus for the even semester on nomenclature. Textbooks and worksheets used by the students were also evaluated. Literature review analysis was carried out based on theory and some relevant previous research findings related to Android-based learning materials designed to optimize student's learning outcomes. Problem identification was carried out by analysing the cause of the problems and the need to develop a new product. The preliminary observations were conducted on the chemistry classes in the school. The activity was complemented by conducting

interviews with chemistry teachers and students who had studied the nomenclature of chemical compounds. In addition, the researchers also reviewed documents containing students' test scores.

Second, planning. The storyboard was developed to visualize the idea and to prepare a model design. The developed android-based application consists of a brief topic introduction, nomenclature rules, oxidation number, type of chemical reactions, problem examples, self-exercises, final evaluation. Third, product draft development and validation. The initial product was developed using Adobe Flash CS6 and converted to *.apk using Android Studio. The product was then evaluated by experts in terms of content and media. The validation was carried out to confirm that the prepared Android-based learning media can be used by student in their learning.

The validity analyses incorporate validator scoring using validation sheets performed by content experts and media experts. Using the Likert scale, the scores of each item in the questionnaire are in Table 1 below.

Table 1. Validation Scoring

Category of Responses	Marks for Items	
	Positive Statements	Negative Statements
Strongly Disagree	1	4
Disagree	2	3
Agree	3	2
Strongly Agree	4	1

Source:(Wicaksono et al., 2014)

The result of the validity score is calculated using the formula below.

$$p = \frac{f}{N} \times 100\ \% \qquad \text{eq. 1}$$

Where P is the percentage of the correct answer, f is the frequency of student answers, and N is the number of students. A learning medium is said to be valid if the average validity score is more than or equal to 61% (Centaury, 2015).

Fourth, Small-scale trial. Ten eleventh-grade students were involved in the small-scale trial; they were selected using purposive sampling technique. They studied nomenclature when they were in the tenth grade. This stage validates and evaluates the effectiveness and feasibility of the learning media using validation sheets and questionnaires. A set of post-test questions were also given to the students to find out the reliability of the questions. The reliability test was conducted through a post-test with a pre-experimental research design in the form of a one-shot case study. The product and the post-test question set were then revised based on the findings and suggestions from the students and teachers.

Fifth, product revision. Product revision was carried out after the product has been applied or tested. This stage was carried out to fix problems that may appear during the initial usage. Sixth, large-scale trial. The revised product was then used in a field trial involving 33 tenth graders who have not been taught about nomenclature. A set of reliable post-test questions was used to explore student's understanding about the topic after they use the mobile app. Before analysing the data, a reliability test was carried out. Here Cronbach's alpha was used. The values are listed in Table 2.

Table 2. Reliability Value

Value	Criteria
0.80 – 1.00	Very High
0.60 – 0.79	High
0.40 – 0.59	Medium
0.20 – 0.39	Low
0.00 – 0.19	Very Low

Source:(Arikunto, 2016)

The question about reliability arises when the obtained reliability value ranges between 0.40 and 0.59, i.e. the medium criteria (Arikunto, 2016). Teacher's and student's responses to the questionnaires were measured using the criteria in Table 3.

Table 3. Questionnaire Scoring Criteria

Questionnaire Result Percentage Interval	Criteria
85% - 100%	Very Good
75% - 84%	Good
60% - 74%	Moderate
40% - 59%	Poor
0% - 39%	Fail

Source:(Fikri & Zubaidah, 2018)

According to Table 3, a questionnaire will be considered good and feasible if the responses to the questionnaire meet the minimum criteria of "good", in this case the percentage is ranges between 75 to 84 (Fikri & Zubaidah, 2018). The effectiveness of the media was measured using post-test questions. Student's scores on the post-test were used as a parameter to determine the effectiveness of the product (Tulbure, 2011).

A structured interview using guided questions was conducted to gain systematic and deep information (Sugiyono, 2015). This technique requires an instrument containing questions dedicated to the chemistry teachers and students to find out their characteristics that are useful for the product development. Observations in this study was conducted to identify the condition of the product used by the chemistry teachers in their teaching activities and to get more information about their classroom learning process. Documents that serve as one of the data of this research was obtained from the teachers. They are student's learning outcomes and other supporting files. The effectiveness of the Android-Based Chemistry Learning Media Measurement techniques was measured using an instrument containing multiple-choice questions.

Here a one-shot case study using the data from the post-test questions was conducted. The product will be considered as effective if the students have the correct answers of more than 75% (called as Kriteria *Ketuntasan Minimum*, abbreviated as KKM, i.e. the minimum completeness criteria) with classical completeness (P) of more than 75% of all students. (eq. 1). The one-shot case study was strengthened with the Z-Test to identify whether or not the android-based learning media is effectively used by students who achieve classical completeness of more than 75%. The formula of the test is as follows.

$$z = \frac{\frac{x}{n} - \pi_0}{\sqrt{\frac{\pi_0 - (1 - \pi_0)}{n}}} \qquad \text{eq. 2}$$

The result of the Z-test is a tscore. If tscore < ttable, the android-based learning media cannot effectively used by students who achieve the classical completeness of more than 75%, and vice versa (Sudjana, 2005).

RESULTS AND DISCUSSION

The need analysis was conducted by interviewing teachers and students (Figure 1a and 1b) resulting in that the teaching and learning process had used the 2013 curriculum, i.e. the K-13 curriculum, with hybrid learning. The classes were conducted both offline and online, so Android-based learning media can be used in this school. This is in agreement with research conducted by Kartini & Setiawan (2019), who found that the media is following the K-13's student-centred method, in which students are active and learn independently (Muhammad et al., 2022).

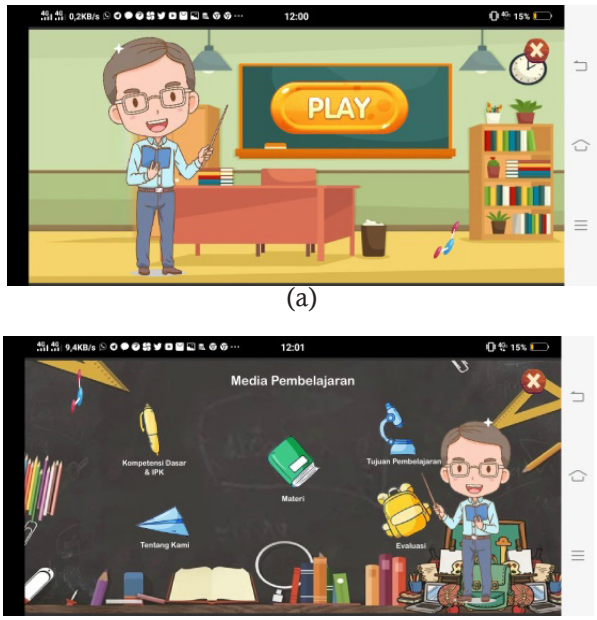
Figure 1. Interview Session with Teachers and Students for Need Analysis (Personal Documentation)

The results of the interview also informed that public secondary schools, particularly in Semarang, use textbooks and worksheets. During the pandemic (2019-2021), online learning was conducted, where teachers provide various learning media using electronic modules and worksheets. However, the use of smartphone-based chemistry learning media in Indonesian high schools as a supporting media, in this case chemistry subject, was still limited.

Some reports mention that android-based apps provide better experiences and make the learning process more interesting (Ulfa et al., 2017; Lukman & Ulfa, 2020; Areed et al., 2021). In this research, we develop a mobile learning application (mobile learning app) that serves as an alternative resource to study chemistry, especially in the topic of inorganic compounds nomenclature. This topic was selected also because the students experienced difficulties in understanding polyatomic compound sub-topics. When they are learning by themselves and practicing making names for compounds, they actually need fast feedback from the teacher. However, they can only clarify their answers when they met the teacher.

Based on the need analysis, the development of android-based learning media was then begun with the storyboard preparation. The items were prepared in a picture format before being assembled in adobe animate software. The final display of the rendered android-based app is shown in Figure 2.

The main menu display consists of 5 items, namely (1) *Kompetensi Dasar* which contains expected basic competencies and indicators of student competency achievement for secondary schools, (2) *Tujuan Pembelajaran* (containing learning objectives), (3) *Materi* (containing brief explanation, nomenclature rules, commercial nomenclature, and questions about student's comprehension), (4) *Evaluasi* (containing multiple-choice tests to evaluate student's cognitive skill of), and (5) *Tentang Kami* (short introduction about the researchers).

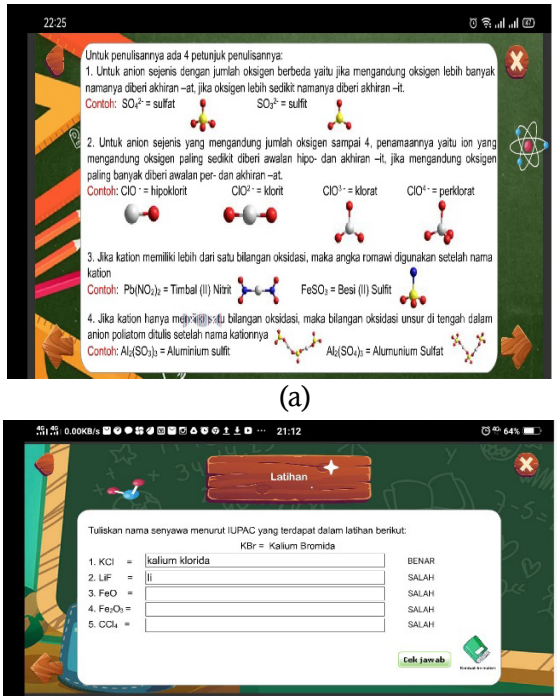


(a)

(b)

Figure 2. Display Screenshots of (a) Main Page and (b) Menu of the Designed Mobile App

The brief explanation was made concisely and clearly discussing the nomenclature of chemical compounds (Figure 3a). The app also provides videos to support explanation on each page and practice questions in every sub-topics. The feature was designed to make students able to learn independently. They cannot move to the next topics before they answer the practice questions correctly (Figure 3b).



(a)

(b)

Figure 3. Display Screenshots of (a) Short Explanation about Anion and Cation Nomenclature and (b) Practice Questions

The application was then validated by experts. The content validation includes coverage accuracy, content quality, language appropriateness, and evaluation, while media validation covers display, physical and content appearance. The validity analysis involved two content experts and two media experts. Their score is based on the validity sheets. The scores are 94.58% for the content and 95.07% for the media. Hence, both aspects are in a good agreement with "very valid". The results imply that the developed mobile app is feasible and appropriate to use (Arikunto, 2016; Pinto et al., 2020). The mobile app was then applied for the main small-scale trial involving ten students who have completed the topic of nomenclature. In this trial, we were expecting an initial perception/response from teachers and students after using the application. The scores of the response are 88.26% from teachers and 83.16% from students, indicating the excellence and the usage simplicity of the mobile app (Lok & Hamzah, 2021). We also received some suggestions about the app such as the following.

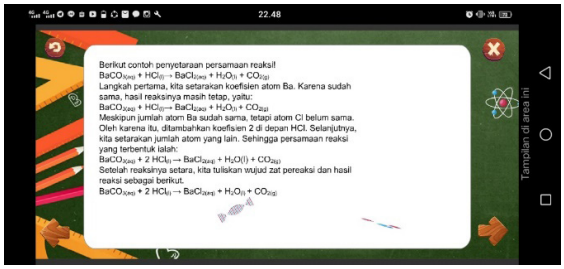
Teacher: "*Media pembelajaran berbasis android sudah baik dan dapat digunakan, akan tetapi perlu dirapikan tampilan teks di-beberapa bagian.*"
"The Android-based learning media is good and applicable, but tidying up in the appearance of text in several parts is necessary."

Students 1: "*Media pembelajaran sudah baik, tapi sebaiknya dikembangkan juga di platform IoS.*"
"The learning media is good, but is should also be developed on the IoS."

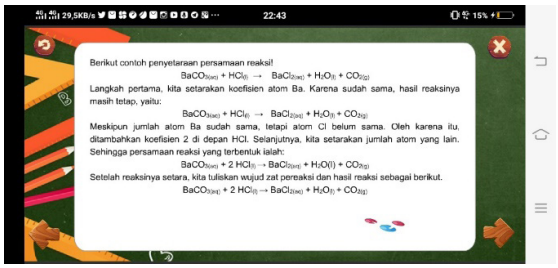
Students 2: "*Sebaiknya ditambahkan animasi agar lebih menarik.*"
"The app will be more interesting if more animations are added."

Students 3: "*Sebaiknya ditambahkan materi senyawa biner….*"
"Please add the subtopic of binary compounds…."

The revisions are made particularly by improving the display and adding sub-topics and practices (Figure 4).



(a)



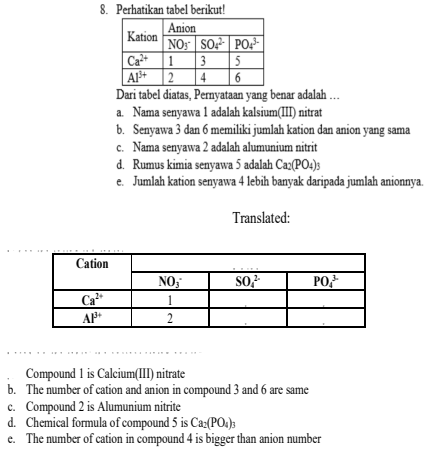
(b)

Figure 4. Display Screenshot of the App (a) Before and (b) After the Revision as Recommended by the Teachers and Students

The small-scale trial was also conducted to test the reliability of the questions provided at the end of the application. There were 25 questions related to nomenclature. The students were asked to answer the questions after they use the mobile app. Then, they were asked to classify the questions based on their difficulty level, resulting in 17 easy and 8 difficult questions. After analysing the students' answers, the reliability test shows the value of 0.95, indicating that the questions are reliable, using the minimum reliably criteria of 0.7 (Tavakol & Dennick, 2011; Matheson, 2019).

Following the revision and reliability test, the mobile app was then implemented for a large-scale trial with 33 students who have not been taught about nomenclature. The result is that 29 students (87.88%) are in the mastery category (scoring 80 to 100) and that four students fail (scoring less than 75). According to the previous report, the mobile app is effective to be used for self-study and to improve student's understanding about nomenclature (Torregrosa-Maciá et al., 2017; da Silva Júnior et al., 2021).

Some students face difficulties in balancing chemical equations (Figure 5).


8. Perhatikan tabel berikut!

Kation	Anion		
	NO_3^-	SO_4^{2-}	PO_4^{3-}
Ca^{2+}	1	3	5
Al^{3+}	2	4	6

Dari tabel diatas, Pernyataan yang benar adalah ...
a. Nama senyawa 1 adalah kalsium(III) nitrat
b. Senyawa 3 dan 6 memiliki jumlah kation dan anion yang sama
c. Nama senyawa 2 adalah alumunium nitrit
d. Rumus kimia senyawa 5 adalah $Ca_2(PO_4)_3$
e. Jumlah kation senyawa 4 lebih banyak daripada jumlah anionnya.

Translated:

Cation			
	NO_3^-	SO_4^{2-}	PO_4^{3-}
Ca^{2+}	1		
Al^{3+}	2		

Compound 1 is Calcium(III) nitrate
b. The number of cation and anion in compound 3 and 6 are same
c. Compound 2 is Alumunium nitrite
d. Chemical formula of compound 5 is $Ca_2(PO_4)_3$
e. The number of cation in compound 4 is bigger than anion number

Figure 5. Question Related to Chemical Equation Writing

The correct answer for question 8 is b; only 7 students (21%) answered correctly. This indicates that the student is difficult to write the correct compound formula from its cations and anions. The developed mobile app provide practice questions to convert chemical formulas to their names and vice versa. However, more practices in chemical formula writing is needed. In the future, the mobile app will provide more practices in chemical formula writing and chemical equation balancing.

The results of the student's post-test were used to analyse students' understanding about the concept of nomenclature that had been taught using the prepared mobile-app. Furthermore, the use of Android-based learning media is expected to have a significant impact on changing student's learning outcomes in chemistry and trigger their enthusiasm in other chemistry topics. The results of the effectiveness test are that the average post-test score is 89.94 and that the percentage of students that accomplish the classical completeness is 87.88%. It was also found that tscore ≥ ttable (8.990 ≥ 1.999), implying that the android-based learning is effectively used by students who achieve classical completeness of more than 75%.

CONCLUSION

The developed android-based learning media on the topic of chemical compound nomenclature has met the validity criteria. The experts have evaluated that the validity of the content and media aspects are 94.53% and 95.07%, respectively. The features of brief nomenclature rules and self-check exercises covered on the learning media also support active learning and self-study for students. The developed mobile app effectively improves student's understanding about inorganic compound nomenclature, indicated by the fact that 29 out of 33 students obtained mastery level.

REFERENCES

Areed, M. F., Amasha, M. A., Abougalala, R. A., Alkhalaf, S., & Khairy, D. (2021). Developing gamification e-quizzes based on an android app: the impact of asynchronous form. *Education and Information Technologies*, *26*(4), 4857–4878.

Arikunto, S. (2016). Proses Penelitian Suatu Pendekatan. *Cet. XIII*.

Astuti, I. A. D., Sumarni, R. A., & Saraswati, D. L. (2017). Pengembangan Media Pembelajaran Fisika Mobile Learning berbasis Android. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *3*(1), 57.

Baldock, B. L., Fernandez, A. L., Franco, J., Provencher, B. A., & McCoy, M. R. (2021). Overcoming the Challenges of Remote Instruction: Using Mobile Technology to Promote Active Learning. *Journal of Chemical Education*, *98*(3), 833–842.

Buendía-Atencio, C., Pieffet, G. P., & Lorett Velásquez, V. P. (2022). WERNER: A Card Game for Reinforcement Learning of Inorganic Chemistry Nomenclature. *Journal of Chemical Education*, *99*(5), 2198–2203.

Centaury, B. (2015). Pengembangan Perangkat Pembelajaran Fisika Berbasis Inkuiri Pada Materi Alat Optik Dan Indikator Dampak Terhadap Kompetensi Siswa Kelas X Sma. *Jurnal Riset Fisika Edukasi Dan Sains*, *1*(2), 80–91.

da Silva Júnior, J. N., Sousa Lima, M. A., Ávila Pimenta, A. T., Nunes, F. M., Monteiro, Á. C., de Sousa, U. S., Leite Júnior, A. J. M., Zampieri, D., Oliveira Alexandre, F. S., de Sousa, U. S., Pacioni, N. L., & Winum, J.-Y. (2021). Design, implementation, and evaluation of a game-based application for aiding chemical engineering and chemistry students to review the organic reactions. *Education for Chemical Engineers*, *34*, 106–114.

Feldt, J., Mata, R. A., & Dieterich, J. M. (2012). Atomdroid: A Computational Chemistry Tool for Mobile Platforms. *Journal of Chemical Information and Modeling*, *52*(4), 1072–1078.

Fikri, H. al, & Zubaidah, E. (2018). Developing Module Of Children Literature To Increase The Students' Critical Thinking. *Lentera Pendidikan : Jurnal Ilmu Tarbiyah Dan Keguruan*, *21*(2), 162.

Franco Mariscal, A. J., Oliva Martínez, J. M., & Bernal Márquez, S. (2012). An Educational Card Game for Learning Families of Chemical Elements. *Journal of Chemical Education*, *89*(8), 1044–1046.

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: an introduction (8th ed.).

Garrido-Escudero, A. (2013). Using a Hands-On Method To Help Students Learn Inorganic Chemistry Nomenclature via Assembly of Two-Dimensional Shapes. *Journal of Chemical Education*, *90*(9), 1196–1199.

Gupta, T. (2019). Game-based learning in chemistry: A game for chemical nomenclature. In *Technology integration in chemistry education and research (TICER)* (pp. 65-79). American Chemical Society.

Kartini, K. S., & Setiawan, I. K. (2019). Pengembangan Media Pembelajaran Interaktif Tata Nama IUPAC Senyawa Anorganik Berbasis Android. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *3*(2), 2615–6091.

Kelley, E. W. (2021). LAB Theory, HLAB Pedagogy, and Review of Laboratory Learning in Chemistry during the COVID-19 Pandemic. *Journal of Chemical Education*, *98*(8), 2496–2517.

Lestari, G., Farida, I., Helsy, I., Kimia, P., Tarbiyah, F., Islam, U., Sunan, N., & Bandung, K. (2021). *Pembuatan Media Cheminosmart Pada Materi Tata Nama Senyawa Anorganik Making Cheminosmart Media on Inorganic Compound Nomenclature Material*. *2*.

Lodge, J. M., Kennedy, G., Lockyer, L., Arguel, A., & Pachman, M. (2018, June). Understanding difficulties and resulting confusion in learning: an integrative review. In *Frontiers in Education* (Vol. 3, p. 49). Frontiers Media SA.

Lok, W. F., & Hamzah, M. (2021). Student experience of using mobile devices for learning chemistry. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(3), 893.

Lukman, I., & Ulfa, A. (2020). Meningkatkan Kemampuan Kognitif Kimia Siswa SMA Melalui Pengembangan Media Pembelajaran Berbasis Android. *JINOTEP (Jurnal Inovasi Dan Teknologi Pembelajaran): Kajian Dan Riset Dalam Teknologi Pembelajaran*, *7*(2), 157–164.

Matheson, G. J. (2019). We need to talk about reliability: making better use of test-retest studies for study design and interpretation. *PeerJ*, *7*, e6918.

Muhammad, R. R., Lawson, D., Aslam, F., & Crawford, M. (2022). The Scientific Approach of The Indonesian 2013 Curriculum: A Comparison with OtherActive Learning Strategies in Mathematics. *Journal of Research in Science, Mathematics and Technology Education*, 155–171

Ningsih, S., & Adesti, A. (2020, March). Android-Based Mobile Learning: Its Effect on Students' Learning Achievement. In *International Conference on Progressive Education (ICOPE 2019)* (pp. 100-103). Atlantis Press.

Pinto, M., Caballero, D., Sales, D., & Fernández-Pascual, R. (2020). MOBILE-APPS questionnaire: Developing and validating a scale to measure the attitudes and perceptions of undergraduate students on mobile information literacy. *Journal of Librarianship and Information Science*, *52*(4), 1063–1072.

Redhana, I. W., Sudria, I. B. N., Hidayat, I., & Merta, L. M. (2017). Identification of Chemistry Learning Problems Viewed from Conceptual Change Model. *Jurnal Pendidikan IPA Indonesia*, *6*(2), 356.

Schlüter, B., Strippel, C. G., Lewalter, D., & Sommer, K. (2022). Everybody Wants to Experiment: Assessing Motivation to Participate in a Chemistry Family Learning Course. *Journal of Chemical Education*.

Sudjana. (2005). *Metode Statistika*. Tarsito.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53–55.

Torregrosa-Maciá, R., Molina-Sabio, M., Lillo-Rodenas, M. A., Silvestre-Albero, J., Berenguer-Murcia, Á., Ruiz-Rosas, R., ... & Cornejo-Navarro, O. (2017). Inorganic Chemistry Teaching Materials for Mobile Learning and/or "Bring Your Own Device" Strategy. In *EDULEARN17 Proceedings* (pp. 2425-2430). IATED.

Treagust, D., Nieswandt, M., & Duit, R. (2018). Sources of students difficulties in learning Chemistry. *Educación Química*, *11*(2), 228.

Tulbure, C. (2011). Differentiated Instruction for Preservice Teachers: An Experimental Investigation. *Procedia - Social and Behavioral Sciences*, *30*, 448–452.

Ulfa, A. M., Sugiyarto, K. H., & Ikhsan, J. (2017, May). The effect of the use of android-based application in learning together to improve students' academic performance. In *AIP Conference Proceedings* (Vol. 1847, No. 1, p. 050008). AIP Publishing LLC.

Vogel, P., & Houk, K. N. (2018). Organic chemistry: Theory, reactivity, mechanisms in modern synthesis. *Journal of Organic & Inorganic Chemistry*, *04*.

Wicaksono, D. P., Kusmayadi, T. A., & Usodo, B. (2014). Pengembangan Perangkat Pembelajaran Matematika Berbahasa Inggris Berdasarkan Teori Kecerdasan Majemuk (Multiple Intelligences) Pada Materi Balok Dan Kubus Untuk Kelas Viii Smp. *Jurnal Pembelajaran Matematika*, *2*(5), 534–549.

Wood, J., & Donnelly-Hermosillo, D. F. (2019). Learning chemistry nomenclature: Comparing the use of an electronic game versus a study guide approach. *Computers & Education*, *141*, 103615.

Yang, J., Yu, H., Gong, C., & Chen, N.-S. (2016). Students' Perceptions and Behaviour in Technology-Rich Classroom and Multi-Media Classroom. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(3).