IJOLAE Indonesian Journal on Learning and Advanced Education

http://journals.ums.ac.id/index.php/ijolae

Developing Interest-Based Teaching Materials in Chemistry Ed: Advancing Pedagogical Practices for Pre-service Teachers Engagement

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DOI: 10.23917/ijolae.v7i2.8741
Received: January 15th, 2025. Revised: February 28th, 2025. Accepted: March 2nd, 2025
Available Online: March 10th, 2025. Published Regularly: May, 2025

Abstract

Interest is an essential element in designing chemistry learning. Teaching students based on interest trains sensitivity and as a reinforcement of chemical content, including triggering students' thinking processes through relevant teaching materials. However, the development of teaching materials focused on the interest approach is still limited, especially in chemistry education in higher education. The research method uses the ADDIE development model (analyse, design, develop, implement, evaluate), with data collection techniques using questionnaires, observation, and documentation, including product feasibility criteria (valid, practical, and effective). The data analysis technique uses a quantitative approach, especially in the aspects of validity to product effectiveness. The results show that the products obtained through the development model and show that the product is declared feasible, with a high validity of 88.80%, practical implementation of 94% (aspect of implementation), and effectiveness in learning management of 94% (aspect of teacher ability to manage learning). Developing interest-based teaching materials is a strategic step to improve students' structure and mental models as prospective teachers, including conceptual understanding and intrinsic motivation. Thus, empowerment of interest influences students' thinking ability, which also helps them experience cognitive transformation as an improvement in mental structure and model in understanding context. This research is also a provision to face various global challenges that are increasingly complex and connected.

Keywords: advancing pedagogical, cognitive transformation, learning innovation, student-centered learning, teachers engagement

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1. Introduction

According to Barke et al. (2012), interest in chemistry education is essential for teaching and learning success. Teaching chemistry is a complex subject that requires a certain level of knowledge and skills to understand (Annisa et al., 2024). In their study, Barke et al. (2012) provided three questions that underlie "interest": (1) In which areas do students have experiences related to everyday life; (2) how do specific environments around the participants influence their image/perception; and (3) what kind of chemical phenomena do students experience daily. These questions are the main foundation that teachers can use to create more profound and meaningful learning scenarios. On the other hand, interest-based projects help students connect chemical concepts to real life. The involvement of interest in learning not only has an impact on cognitive development but also strengthens the perception, motivation, and behaviour of participants (Barke et al., 2009; Espinosa et al., 2013; Harefa et al., 2020; van Dinther et al., 2023; Wisudawati et al., 2022). Barke et al. (Barke et al., 2012) emphasised that interest allows the construction of scientific mental structures and models so that students understand learning chemistry deeply.

Achieving a mental model can be achieved by influencing motivation internally. In the context of interest, Barke et al. (2012) explained that intrinsic motivation is the leading indicator in implementing the concept of interest in learning. Interest-focused learning provides an internal space that encourages students to understand a context in depth. Intrinsic motivation is also the essential element that impacts the construction of participants' mental structures and models (Barke et al., 2012; Gagne, 1970; Mezirow, 1997; Smith et al., 2024). Mental models are highly expected so students can understand and explain the studied phenomena (Barke et al., 2012; Dacosta et al., 2017). Forming a scientific mental model is a form of cognitive transformation that can effectively reduce students' conceptual errors (Locatelli & Davidowitz, 2021; Sunyono, 2018). Therefore, the growth of intrinsic motivation through an engaging approach can be a significant educational experience, allowing students to experience cognitive progress, behavioural changes, and new paradigms.

Many studies use various approaches to influence a person's interest in education. Digitalisation is one component related to the aspect of interest. For example, Prameswari et al.'s (2024) research used Instagram media to increase participants' interest in photography. In its implementation, social media can increase participants' interest without gender bias (Prameswari et al., 2024). Other studies have also found that interventions in science learning can influence students' interests (Lin et al., 2013). This influence has an impact on increasing students' interest in learning science. Therefore, this study provides empirical evidence that interventions in learning science can develop students' interests progressively and cumulatively (Lin et al., 2013). Still, in the scientific field, research has found that participants' interests influence motivation in learning physics in the learning process (Kwarikunda et al., 2020, 2021). Paying attention to aspects of interest in learning can strengthen participants' thinking skills, such as critical thinking, self-efficacy, perspective, and problem-solving (Bammer et al., 2023; Barke et al., 2012; Kwarikunda et al., 2020; Phuong Dung et al., 2023; Wang & Lewis, 2020).

According to Milutinović (2024), a person's character and motivation differ in understanding a context. Lack of motivation can interfere with students' learning activities (Prayitno et al., 2019; Rajiani et al., 2023; Susanti et al., 2023). The social environment and psychological conditions are part of what influences the interests of participants (Milutinović, 2024). Therefore, relevant and appropriate learning for students' needs dramatically determines the success of learning (DeWitte, 2022; Kwarikunda et al., 2021; Milutinović, 2024). On the other hand, increasing interest can be achieved by developing audio-based teaching materials (Silva et al., 2024). In addition, these teaching materials also motivate and participate participants in the learning process. Technology integration effectively allows participants to explore their understanding of learning a material (Silva et al., 2024). Attention to requests is also given to prospective chemistry teachers to determine their interest in a material context (Mumba et al., 2018). Although further studies are needed, the study by Mumba et al. (2018) provides information that prospective teachers' interest in certain materials can be a strategic step in developing relevant learning concepts. Treatment that meets their needs, especially interests, makes prospective teachers more understanding and explorative in understanding knowledge (Mumba et al., 2018). Thus, integrating interests in learning components can potentially improve participants' understanding, motivation, perspective, and cognition.

The development of interest-based references is becoming increasingly important, considering that interest is integral to constructing scientific knowledge. To achieve interest-based references, a scientific method is needed to obtain results, namely empowering interest in building a scientific mental model (Barke et al., 2012). In the context of research, the development method is the right step in designing and producing interest-based teaching references, including aspects of feasibility in them (Barke et al., 2009, 2012; Branch, 2009; Cao & Meng, 2022; Dick et al., 2015; Kwarikunda et al., 2020; Schweder & Raufelder, 2021). The results of the development need to include relevance, that the content of learning resources must contain the context of everyday life and be close to the phenomena experienced by students. The feasibility of teaching materials must be assessed by experts so that the product is feasible and scientific, including practicality in implementation. In addition, conceptual understanding (Barke et al., 2012), motivation (Barke et al., 2012), and student perceptions can be measured through aspects of learning effectiveness (Barke et al., 2012; Helix et al., 2022; Taylor & Sobel, 2011; Trilling & Fadel, 2009). Thus, this systematic design and testing development ensures the functionality of the developed teaching materials and relevant learning tools in strengthening students' scientific knowledge, attitudes, and thinking skills.

The presentation of learning that focuses on students' interests allows the teacher to achieve substantive motivation within the students. This means that this achievement makes teachers not need to think about extrinsic motivation because interest-focused learning has facilitated the forming a scientific cognitive structure (Barke et al., 2012). In addition, interest-focused learning greatly supports the occurrence of mental conflict and the growth of positive emotions in students, so interest-focused learning needs to be developed as a form of cognitive transformation (Barke et al., 2012; Damianakis et al., 2020; Mezirow, 1997; Winarti et al., 2022). Cognitive transformation is considered a bridge of knowledge so students can view science learning more profoundly and obtain the most profound meaning of what is learned, including realising long-term motivation (Barke et al., 2012; Mezirow, 1997).

Although many studies have been related to developing teaching materials in chemistry education, specific research focusing on the interest approach is still limited. Most studies focus on integrating technology, strategies, and methods to improve interest. Still, this research is how to analyze and empower the interest aspect of students as a basis for developing teaching materials. In addition, the available teaching references are sometimes not fully designed based on interests and address the negative stigma of students learning chemistry. Teaching references still show a gap in the needs of students because each student has their character and identity. The research concept emphasizes that producing interest-based teaching materials is a medium for constructing scientific knowledge and trains students' attitudes and thinking skills as prospective teachers to face increasingly complex global challenges.

2. Method

a. Research design

The research uses a Research & Development (R&D) design with the ADDIE development model, which includes the stages 1) Analysis, 2) Design, 3) Develop, 4) Implement, and 5) Evaluate (Branch, 2009). Product eligibility criteria are seen from validity, practicality, and effectiveness (Creswell, 2012; Rosalina Rawa & Sutawidjaja, 2016; Singer & Nielsen, 2012). In addition to research products, several data are also targeted, such as interest analysis, initial knowledge analysis, learning outcomes, and feasibility test data.

b. Sample, Data Collecting, and Analysis

The research sample is chemistry education students from the 2021 and 2022 intakes contracting the chemistry school two course and chemistry learning media. The selection of courses is considered appropriate for implementing research, especially for the products being developed. Data collection techniques use questionnaires, observation, and documentation techniques with variations in quantitative data analysis. Other explanations in the research are explained at each stage of the ADDIE model adopted, including the data and analysis used.

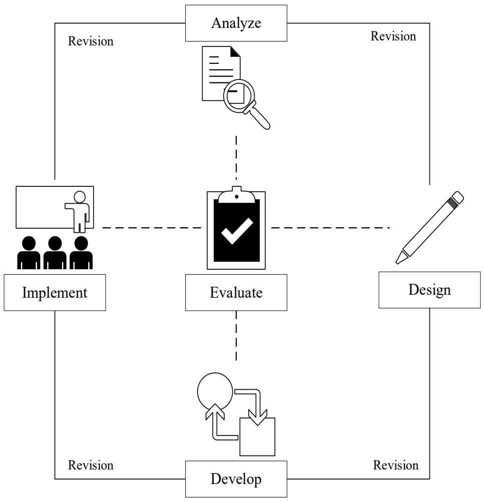

Figure 1. ADDIE Development Model Procedure (Branch, 2009)

The initial stage of ADDIE is "analysis". At this stage, the researcher already knows the learning objectives of each course in the lesson plan document they have. The stages needed are conducting a needs analysis, such as initial knowledge and interest analysis. Initial knowledge analysis uses test techniques in the form of dichotomous or multiple-choice format questions. Initial knowledge analysis uses the Rasch model by covering several criteria: MNSQ, SZTD, and PT Mean-Corr (Sumintono, 2018; Sumintono & Widhiarso, 2015). This criterion aims to check the suitability of items that do not fit (misfit items) and the participants (person fit). The following criteria are referred to (Sumintono & Widhiarso, 2015):

- Received Outfit Mean Square (MNSQ) value: $0.5 < MNSQ < 1.5$
- Received Outfit Z-Standard (ZSTD) value: $-2.0 < ZSTD < +2.0$
- Point Measure Correlation (Pt Mean Corr): $0.4 <$ Pt Measure Correlation < 0.85

For interest analysis, interest data were collected using a questionnaire technique using various statements taken from Barke et al.'s book "essentials in Chemical Education" (2012). The statistical approach is a data analysis technique used to determine student interests (Kyriazos & Stalikas, 2018; Wright & Masters, 1982). The next stage is "design", where researchers design various components involved in learning, especially teaching materials, which are the main products of the research. In this stage, prototypes of teaching materials and “graduate learning outcomes” are produced in each course subject of research implementation. The next stage is the “development” stage, where the designed product (teaching materials) is validated or tested for feasibility by several experts. Each expert is given a validation sheet to fill in and is provided with information.

For validity and practicality, using the assessment approach from Borich (1994) to determine the level of feasibility of the product obtained, with a percentage of agreement = it is said to be good if it has a reliability coefficient ≥ 0.75 or ≥ 75% (Siagian et al., 2023; Susantini et al., 2022). Then, proceed to the "implementation" stage, where the interest-based learning scenario has been designed, especially the teaching materials that can be used by teachers in the implementation of the selected courses. The next step is "evaluation," where the implementation results in the previous stage are analyzed based on the effectiveness aspect. This aspect analyzes student learning outcomes consisting of assignment scores, midterm exams, and final semester exams. A statistical approach is also used to recapitulate learning outcomes.

3. Result and Discussion

a. Research Results

The research results show that teaching materials have been developed through the ADDIE development model, especially in obtaining feasible criteria for the developed teaching materials. The following are the results of each ADDIE stage and a discussion of the findings obtained.

b. Analysis Stage

The results of the initial knowledge analysis with the Rasch model show that there are students with high abilities and others with low skills. This data is supported by Figure 2 below, which is the variable maps graph (Almubarak et al., 2023). The left side is the student response pattern, while the right is the distribution of item difficulty levels. The code "#" indicates 3 (three) students, and the sign "." indicates 1 to 2 students. This means that if the code is lined up like "###.", then the code indicates > 5 people, indicating equality of ability (person measure).

Logit is a logarithmic transformation of the probability of a person's success in answering an item based on the suitability between the student and the difficulty of the item (question). Positive and high logit values indicate that the student can answer questions well. At the same time, the item is considered to have the highest difficulty level.

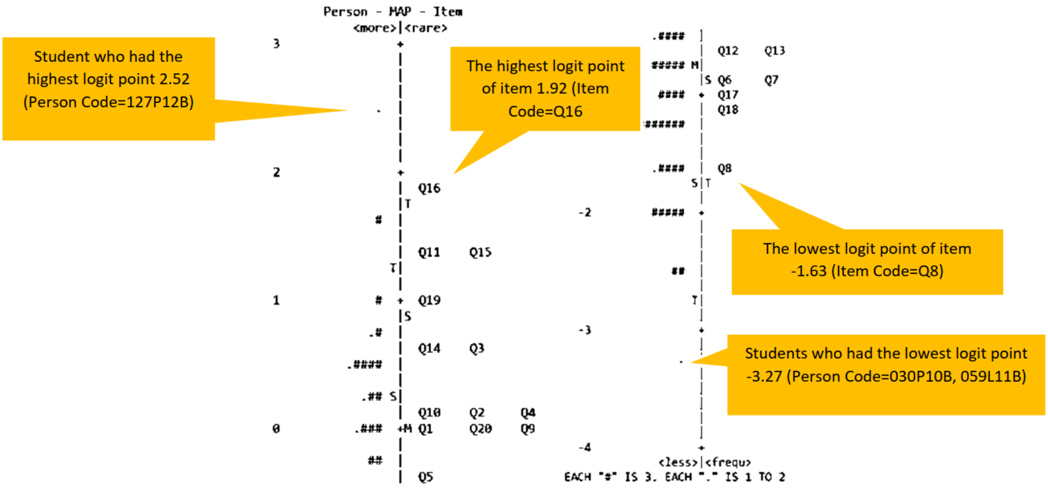

Figure 2. Graph of Wright variable maps to see the student's logit value and item difficulty level (Almubarak et al., 2023)

Figure 2 above shows the code "." On the left side (person) is the student with the highest ability with code 127P12B and a logit value of 2.52, while students 030P10B and 059L11B, logit value (-3.27) are students with the lowest ability. On the other hand, questions with a high level of difficulty have a logit value of 1.92 (Q16 is question number 16) on the right side of the image. Then, question number 8 or Q8, is the question with the lowest difficulty level (logit value = -1.63), meaning that question Q8 is the easiest to answer (Almubarak et al., 2023). Students have different cognitive abilities, so this data is used to design learning.

In addition to the Rasch model data, the results of the interest analysis were also obtained at this analysis stage. For interest in the context of "everyday life", the topic of food has the highest percentage of 90%. In comparison, students tend to dislike the discussion of "alcohol", with a percentage of only around 2.5%. The topic of drinks and cosmetics has the same rate, which is the second highest at 71.30%, while the topic of "actions to improve the environment" has a percentage of almost 60%. Other issues, such as fertilizer, cement, fuel, cleaning powder, and bathroom cleaners, have a rate of no more than 10%. Statistical data on the "everyday life" aspect shows that students prefer discussing "food" over other topics. Thus, food can be an initial analysis for implementing learning as a project idea.

Next, the aspect of "nature and environment", the most popular topic is waste management, with a percentage of 71.30%. In comparison, acid rain is the topic with the lowest percentage of 2.50%, meaning that the topic of acid rain tends to be disliked by students. The next topic is "chemical processes," which has several topics. Based on the analysis, textile colouring has the highest percentage of 64.20%, while glue has the smallest percentage of 8.60%. In addition, rocket engines, fuel cells, photo production, and blasting or explosive processes have 30-50% percentages. Other topics, such as batteries, metal alloy processes, and galvanising, have percentages below 25%.

Data on the topic of "chemical industries" shows that drugs have the highest percentage of 80.20%. In comparison, the smallest percentage, 22%, is the topic of steel and metal, meaning that drugs are the most popular topics for students to discuss. Topics that have a percentage below 50% are gasoline and diesel, sulfuric acid, sugar, salt minerals, plastics, and paint (except steel and metal). In comparison, paper and wood are topics that have a percentage of 51%. Regarding interest, drugs are the main point when working on research projects because this topic is very relevant to human activities. Thus, the results of the interest analysis presentation obtained can be used as a basis for assignment formats, including project development contained in teaching materials.

c. Design Stage

The implementation plan for the development of the product is for the chemistry learning media and school chemistry two courses. This course is appropriate because it has the potential to accommodate skills relevant to the 21st century in chemistry education, namely problem-solving skills, collaboration, and creativity. These skills are essential to equip students with analytical and innovative skills in responding to learning challenges in the digital era. The teaching material-based project is designed to help students align pedagogical skills with modern learning needs. In this context, prospective teachers must understand the science content (chemistry) and the ability to use technology in the learning process. This approach emphasizes that each course learning objective is achieved optimally by promoting meaningful and contextual learning experiences.

The results of the previous analysis showed that students at the middle level have different levels of cognitive ability. Some students have low ability levels, while others are at the medium level. From the graph (analysis stage), one person has the highest ability level. From the item aspect, only a few students can answer the most difficult items, while most students can access items with a low difficulty level. A holistic and adaptive teaching approach is needed to accommodate student differences. Thus, teaching materials are designed to bridge this gap, ensuring each student has a relevant and meaningful learning experience.

The results of the interest analysis also show several hats with the most extensive presentation, namely food at (90%), while the smallest is 64.20% (textile dye). Other data also shows 72% for paper recycling, glass, etc., and medicines at 80.20%. However, other topics must also be considered to make the project work more varied for each student. Interest analysis is carried out on college students, while cognitive analysis is done on high school students. The goal is to discover each group's preferences and learning needs and adapt to individuals' mental abilities and interests. Therefore, the teaching materials developed attract students' interest and challenge them cognitively, especially as future teachers.

Figure 3. Cover of Teaching Materials Related to Interests (Almubarak & Saadi, 2023)

Learning objectives are certainly the primary reference when developing this teaching material. Learning outcomes use the 2 courses mentioned earlier. The following are the learning outcomes in question.

Learning outcomes of the "School Chemistry 2" course

a. Able to apply didactic-pedagogical concepts and principles as well as chemical science by utilizing science and technology to plan, manage classes, implement and evaluate learning innovatively
b. Mastering didactic-pedagogical-chemical concepts and principles to support professional duties as educators
c. Making appropriate decisions based on the assessment of material characteristics (content knowledge), student characteristics, methods, models, approaches, strategies and media that are appropriate to be applied actively and innovatively in the learning process in each educational unit

Learning outcomes of the "Chemistry Learning Media" course

a. Able to analyze, synthesize, and evaluate problem-solving of various material characteristics (content knowledge), pedagogical theories (pedagogical knowledge), and ICT (technological knowledge) and their applications for chemistry learning innovation
b. Identifying problems and determining alternative solutions based on theories and research findings, as well as designing and implementing them in chemistry education research
c. Applying digital competencies in chemistry learning and relevant daily life
d. Integrating chemical concepts, chemical pedagogical knowledge, curriculum, methodology, media, evaluation, management class, and ICT in chemistry learning (TPACK-technological pedagogical and content knowledge), solving chemistry education problems
e. Internalizing academic values, norms, and ethics

The learning outcomes in the above courses are components adapted to the teaching materials developed, including considering the results of the previously conducted needs analysis.

d. Development Stage

The development stage is a continuation stage after the previous design stage. In the research context, this stage includes the revision process, instrument validity analysis, and determination of learning concepts in implementing products, including selecting learning models, methods, approaches, media, etc. In addition, the selection of validators is based on expert expertise, so the criteria for eligibility are expected to be met in the developed product. The following are the results obtained at the development stage.

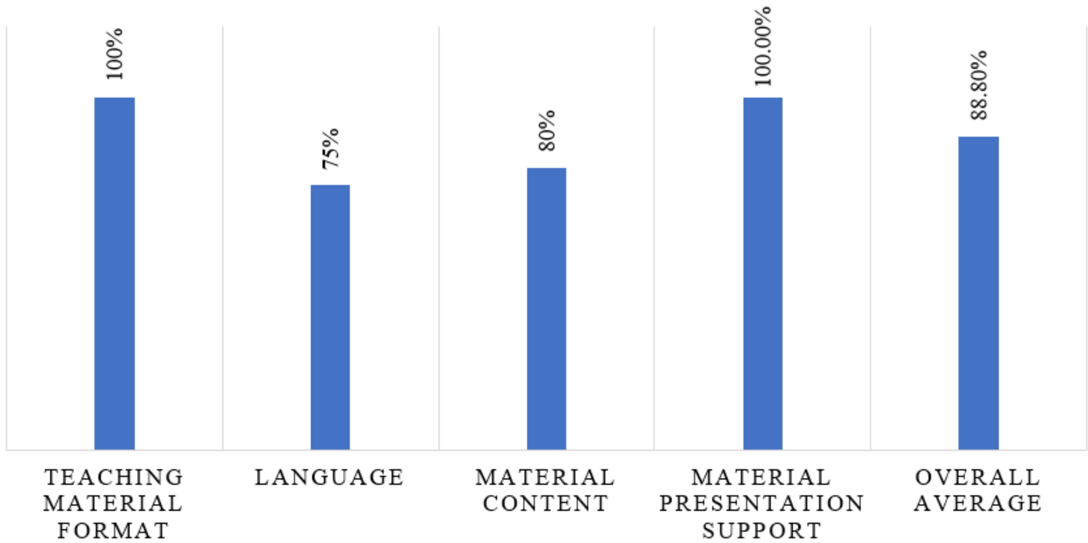

Figure 4. Results of Validation of Teaching Materials by Experts
Description: Percentage of Agreement = [A/(A+D) x 100%] (Borich, 1994)
Description: is said to be good if it has a reliability coefficient of ≥ 0.75 or ≥ 75%.

Validity refers to the suitability, meaningfulness, truth, achievability, and functionality of an instrument or procedure based on the research design (Muntholib et al., 2018; Nur Azizah et al., 2022; Sofnidar & Yuliana, 2018). The validator selected is a validator who has an educational background that is relevant to the context of the module development being carried out. The validator selected is a lecturer with a background in analytical chemistry and chemical education.

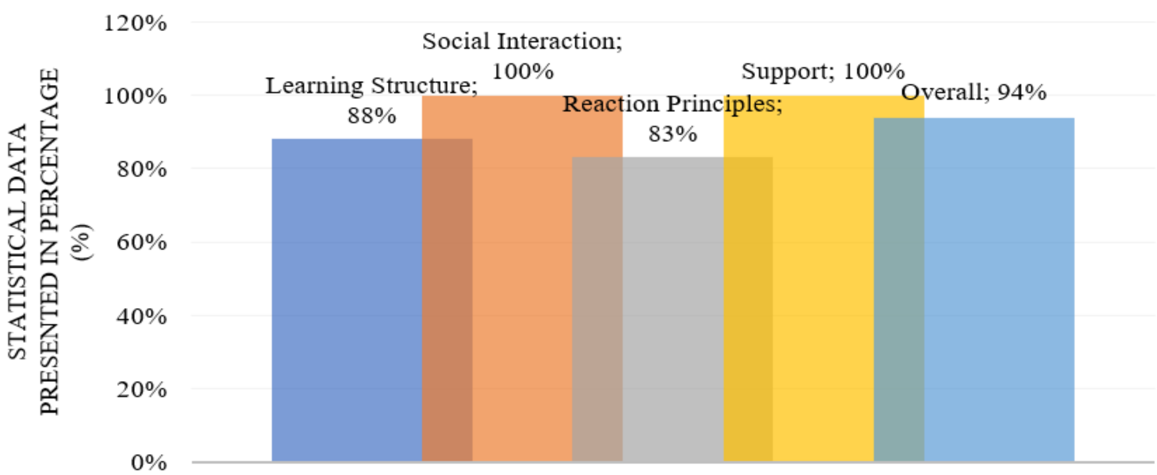

Figure 5. Implementation of Open Materials in Learning for Practical Aspects

The purpose of practicality is to determine to what extent the materials contribute and change students' mindsets in constructing their knowledge. The expected understanding is that students are aware of the presence of science in human life. Implementing the product can be one of the benchmarks for the success of the developed teaching materials.

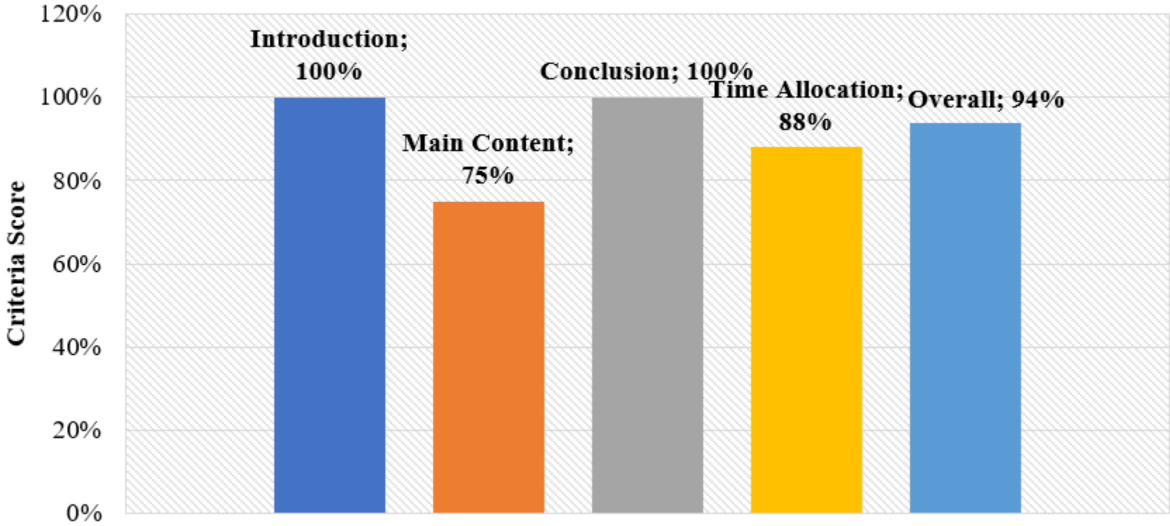

Figure 6. Effectiveness in Learning Management for Practical Aspects, Especially Teachers' Ability to Manage Learning

The image above shows that the ability of teachers to manage learning with the developed design is considered "very high", with a total presentation of around 94%. At the same time, other assessments, such as introduction, core, and closing, each have a percentage of 100%, 75%, and 100%. Thus, the expert shows that classroom management by teachers using interest-focused teaching material products is stated to be appropriate and according to plan.

e. Implementation Stages

In practice, students make presentations on their projects, primarily related to the interests chosen from the needs analysis results. This presentation aims for students to discuss and criticize each other's project results. Criticism of the discussion that occurs can trigger a paradigm shift related to the context being discussed/presented. Paradigm improvements certainly have an impact on student's mental structures and models. Thus, students experience a cognitive transformation that ends in the growth of a scientific mental model. Below is a description of students' implementation of interest-based learning, accompanied by observers as objective assessors. This presentation discusses how industries such as "The Banjarmasin-Sasirangan typical cloth" are discussed chemically and culturally. This project is termed "#self-developed project", meaning finding an understanding of science through the study of tradition. Tradition/locality is also involved in this teaching material, with a science-based discussion. This is also relevant to the study of international science standards, which discuss the context of science and society in learning (NGSS, 2013). This project allows students to deeply examine the role of science in society.

Figure 7. Implementation of Learning, Including Project Presentations, Discussions, and Question-and-Answer Sessions

Students also presented another project called #EducativeCampaign, which used their social media as an educational campaign. This project was inspired by the University of Stanford's findings on Generation Z, which state that young people today are very active in using technology, including social media (DeWitte, 2022). This project is considered a student response to the digitalization era and their preparation for facing global challenges, especially in teaching and learning. This project is carried out individually with the intention of training students' problem-solving abilities in analyzing and synthesizing various literature integrated into the project. This project is also a medium for cognitive transformation for students (prospective teachers) so that they gain scientific knowledge related to chemistry and new paradigms (DeWitte, 2022; Obreja, 2024; Recuero, 2024; Rui et al., 2017; Taylor & Sobel, 2011; Trilling & Fadel, 2009).

Figure 8. Examples of Student Projects Related to Sodium Chloride in Salt, Use of Mouthwash, and Digital Media

Criticism and input from fellow students, observers, and lecturers become reflection materials for each individual/group that presents. The projects are expected to produce knowledge and construct students' mental structures and models to find meaning in the context discussed and studied. Thus, implementing teaching materials in the learning process is considered successful in producing thinking based on interest analysis. The projects worked on also represent the learning achievements of graduates, who are the primary targets.

f. Evaluation Stage

This evaluation shows the impact of interest-focused teaching materials and the student's journey in the ongoing learning process. The effect can be seen in the learning outcomes, such as the cognitive learning outcomes obtained by students. The graph below summarises the cognitive learning outcomes of Chemistry Course 2 and chemistry learning media, which are presented in a range of 0-100 based on assignment scores, midterm exams (ME), and final semester exams (FSE). In the chemistry learning media course, there was an increase in assignment scores of almost 73, ME around 80%, and FSE above 82. These results indicate that the learning methods, including developed teaching materials, are effective.

In contrast, for Chemistry course 2, the initial performance obtained a high score with an average assignment of around 80, which then increased in the ME to around 82 but decreased to around 75 in the FSE. These results indicate that students' cognitive performance is hampered. Thus, interest-focused learning tends to be more effective in media courses than in chemistry school 2. However, an in-depth evaluation of the various attributes in the implementation of learning is needed.

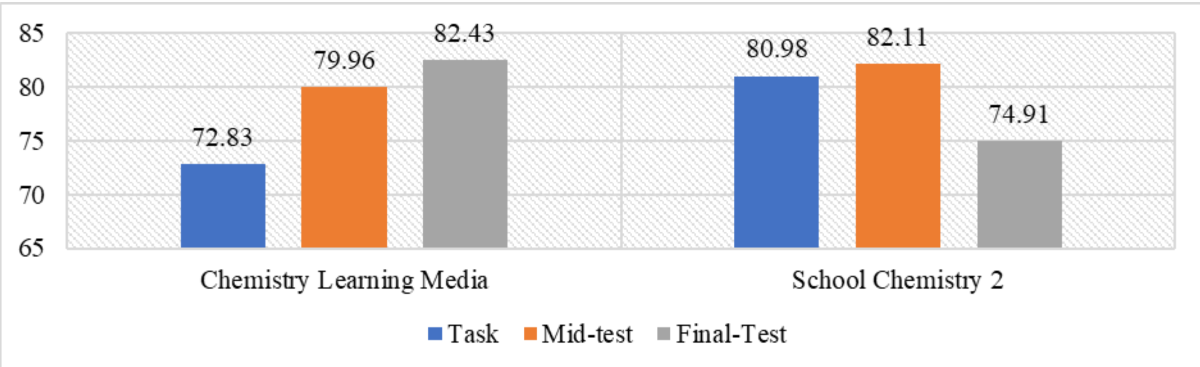

Figure 9. Recapitulation of Student Learning Outcomes, Including Assignment Grades, Mid-Term Exams, and Final Semester Exams

In addition to learning outcomes, the evaluation also reviews the feasibility of teaching materials based on the validity, practicality, and effectiveness tests of teaching materials. For validity, "teaching material format and material presentation support" have a validity value of 100%, while others are not below 75%. For practicality in the "Textbook Implementation" aspect, it shows that the teaching materials are declared practical with all criteria values above 82%, such as learning structure, social interaction, reaction principles, and support.

Then, the practicality for the "Teacher's Ability to Manage Learning" aspect has met the criteria with each value in the feasible range, namely 75% - 100%. For effectiveness, it also shows that student learning outcomes have increased, although, in the school chemistry course, there was a decrease in the final exam score. However, the teaching materials developed can provide innovation in chemistry learning. Thus, the teaching materials are declared feasible for use and implementation.

g. Discussion

Research confirms that interest-based teaching materials have a significant influence on increasing students' intrinsic and cognitive motivation towards chemistry material. These results follow the study by Barke et al. (Barke et al., 2012), which showed that involving "interest" in learning not only encourages participants psychologically but also supports the improvement of participants' scientific mental structures and models. For example, interest analysis shows that students have a high interest in topics that are closely related to their lives, such as food (90%), cosmetics (71.3%), waste management (71.3%), and other topics contained in the subject of interest. This finding supports previous studies that increasing intrinsic and cognitive motivation is influenced by studies that are relevant and related to aspects of participants' lives, including obtaining meaningful learning experiences (Carle et al., 2020; Espinosa et al., 2013; Suja et al., 2020; van Dinther et al., 2023).

Learning references that are directly related to the lives of participants are evident in the context of this study. The experiences and learning outcomes obtained show that the teaching materials are effective in improving and deepening students' understanding of chemistry so that the nature of abstract material becomes very applicable and interesting. For example, the project that was worked on (#self-developed project), which integrates local traditions, has provided space for students to relate chemistry to the socio-cultural context. These results align with Mezirow's (1997) thoughts, who emphasized the importance of participants experiencing a cognitive transformation to construct new paradigms through meaningful learning. In addition, the #EducativeCampaign project shows that integrating technology, such as social media, supports students' interest-based learning experiences (Barke et al., 2009, 2012; DeWitte, 2022). This project also trains skills needed in the 21st century, such as critical thinking (Easa & Blonder, 2024; United-Nation, 2023), problem-solving (Asmussen et al., 2023; Hunter et al., 2021), representation (Barke et al., 2012; Keiner & Graulich, 2021; Parobek et al., 2021), and mental model refinement (Barke et al., 2012; Havsteen-Franklin et al., 2023).

In terms of implementation, several gaps are obtained in this research, which certainly need attention. First, the results of the analysis of non-dominant interests, such as acid rain (2.5%), textile dyeing (64.2%), fuel cells (35.80%), plastic (37%), and bathroom cleaners (7.5%), also emphasize the need for flexible and accommodating teaching materials to the very diverse preferences of students. Second, cognitive learning outcomes (average final exam score = 74.91) in the chemistry course of school 2 have decreased. These results indicate obstacles in the student learning experience, including in working on projects. Therefore, adaptive learning is needed to meet the needs of inclusive students. Third, the impact of implementing learning with interest-based teaching materials still needs to be explored, especially the long-term effect on students' thinking skills, especially in solving problems through projects. Problem-solving skills are essential for students in chemistry learning to build scientific understanding and improve mental models (Asmussen et al., 2023; Barke et al., 2012; Hunter et al., 2021).

Research shows that empowering interests can strengthen teachers in teaching students, where previously "interest" was the orientation with technology integration (Prameswari et al., 2024). Some studies use interventions, including digital features, to influence or increase participant interest; this research uses interest as a basis for developing teaching materials to improve student understanding of a material (DeWitte, 2022; Kwarikunda et al., 2020; Lin et al., 2013; Prameswari et al., 2024). Other research also shows that participant motivation is influenced by interest (Kwarikunda et al., 2020, 2021), while the results of this research empower interest to impact student motivation, especially intrinsic motivation. Thus, teaching materials based on needs (interest) analysis can strengthen students' thinking skills such as critical thinking, self-efficacy, perspective, and problem-solving (Bammer et al., 2023; Barke et al., 2012; Kwarikunda et al., 2020; Phuong Dung et al., 2023; Wang & Lewis, 2020).

This study offers a new concept, especially in the context of developing interest-based teaching materials, where previously, several chemistry education studies focused on developing thinking skills in higher-level materials (Atkinson et al., 2020; Frey et al., 2020; Frost et al., 2023; Mattox et al., 2023). The development of measurement tools also tends to be recommended by several studies for those who have difficulty levels and cognitive levels of students (Asmussen et al., 2023; Wackerly, 2021), including the integration of several scaffolding interventions, coordination classes and other strategies (Bammer et al., 2023; Braun & Graulich, 2024; Dood & Watts, 2022; Du et al., 2022). Therefore, this study is one of the essential references for teachers in supporting students' cognitive development as a basis for improving the structure of mental models through interest (Barke et al., 2012). The study results emphasize the importance of transformation for students to gain perspectives and in-depth knowledge based on learning experiences that support students' interests and needs (Barke et al., 2012; Easa & Blonder, 2024; Mezirow, 1997).

In practice, implementating interest-based projects emphasizes that chemistry learning is theoretical and applicable because it relates students' lives. The projects that are carried out also show that chemistry can be adapted in various contexts, including socio-cultural ones. In addition, the project work reflects how students' skills in using technology as a provision for designing creative and collaborative learning when they become teachers. Thus, this research has a strong foundation for building intrinsic motivation, mental models, and skills that are relevant to the 21st century theoretically and practically.

The research results show that interest-based teaching materials impact students, especially in the pattern of learning outcomes obtained. The structure of the teaching materials includes general material on the importance of interest and examples of chemical materials with a contextual approach. Contextual refers to the discussion of current issues and their relationship to human life, which is also taken based on interest analysis. In other words, the results of the interest analysis are used as the basis for developing case examples in the teaching materials, which students themselves then develop through various projects in class. Improved learning outcomes, project results, and cognitive development reflect that students have experienced a transformation of mental models. Although the growth is not yet fully optimal, this teaching material provides new literacy for students as prospective chemistry teachers.

In the context of Discipline-Based-Educational Research (DBER), this research shows the need to identify the effectiveness of learning at the tertiary level, especially in chemistry education (Singer & Nielsen, 2012). Many materials in chemistry education courses still need to be updated to teach students various concepts. Empowering interests as a basis for designing learning is a strategic step to improve students' conceptual understanding and strengthen their mental structures and models (Barke et al., 2009, 2012; Singer & Nielsen, 2012). This research can also be used by students to be imitated both theoretically and practically from the trial results. This utilization has the potential to help students prepare themselves as prospective teachers in the future. Examples of projects in teaching materials are a medium for students to adapt to various global challenges that are increasingly complex and interconnected (DeWitte, 2022; King, 2012; Rahiman & Kodikal, 2024).

Several limitations in this study need attention. First, the topics discussed in class are only statistically dominant, so variations in other issues are still challenging to implement. Second, the holistic achievement of interest-based learning has not been evaluated in depth for long-term needs. Therefore, further studies are needed to determine how much this approach fully supports students' thinking skills, especially problem-solving skills. Third, the decline in students' cognitive learning outcomes in the chemistry course of school 2 indicates that additional strategies are needed to support the application of complex chemical concepts, but are understood in depth. Fourth, the samples used were only two courses, so the results obtained are not strong enough to be generalized because the application to other classes will likely experience different results. However, this study significantly contributes to the development of interest-based teaching materials. This contribution is a strategic step to equip students to face increasingly complex and connected global challenges.

4. Conclusion

Research shows that developing interest-based teaching materials effectively improves students' conceptual understanding of the studied material. Developing these teaching materials also makes it easier for students to achieve learning objectives, especially in school chemistry 2 and chemistry learning media. The results impact students' cognition and motivation in the thinking process, considering that they are prospective chemistry teachers who must be equipped with many references in future learning. The projects worked on by students significantly contribute to students' competence as prospective teachers. The project trains students to become adaptive and resilient prospective teachers, considering that digitalization is increasing exponentially. Digital culture is an essential component in the 21st century, so this research reflects the presence of renewal in the field of chemistry education, especially in the context of interest-based teaching materials. Although considered successful in concept and implementation, the research results show several challenges, such as limitations in the context of sample representation, variations in interests that have not been fully covered, and evaluation of long-term impacts. Therefore, further studies are a strategic step in overcoming existing limitations and developing teaching materials more adaptive to chemistry education students' needs. However, this study confirms that the interest-based approach has significant contribution and potential as a basis for designing relevant, meaningful, and transformative chemistry learning to impact learning as a whole positively.

5. References

Almubarak, A., Saadi, P., Prayogi, R., & Maldini, P. P. (2023). Assessing Students Understanding of Chemical Bonds

Material by Rasch Modeling. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, *5*(3), 217–232. https://doi.org/10.23917/ijolae.v5i3.22242

Almubarak, & Saadi, P. (2023). *INTEREST Focused-Learning: sebuah desain pembelajaran abad ke-21 berbasis minat untuk melatih keterampilan sosial dan interaksi lintas budaya calon pengajar kimia.* CV Banyubening.

Annisa, D., Sutrisno, H., Laksono, E. W., & Yanda, S. N. (2024). Evaluating Students' Academic Resilience in Chemistry Learning: Insights from a Rasch Model Analysis. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, *6*(3), 328–349. https://doi.org/10.23917/ijolae.v6i3.23522

Asmussen, G., Rodemer, M., & Bernholt, S. (2023). Blooming student difficulties in dealing with organic reaction mechanisms - an attempt at systemization. *Chemistry Education Research and Practice*, *24*(3), 1035–1054. https://doi.org/10.1039/d2rp00204c

Atkinson, M. B., Popova, M., Croisant, M., Reed, D. J., & Bretz, S. L. (2020). Development of the Reaction Coordinate Diagram Inventory: Measuring Student Thinking and Confidence. *Journal of Chemical Education*, *97*(7), 1841–1851. https://doi.org/10.1021/acs.jchemed.9b01186

Bammer, G., Browne, C. A., Ballard, C., Lloyd, N., Kevan, A., Neales, N., Nurmikko-Fuller, T., Perera, S., Singhal, I., & van Kerkhoff, L. (2023). Setting parameters for developing undergraduate expertise in transdisciplinary problem solving at a university-wide scale: a case study. *Humanities and Social Sciences Communications*, *10*(1), 1–11. https://doi.org/10.1057/s41599-023-01709-8

Barke, H.-D., Harsch, G., & Schmid, S. (2012). Essentials of Chemical Education. In *Angewandte Chemie International Edition, 6(11), 951–952.* Springer.

Barke, H.-D., Hazari, A., & Yitbarek, S. (2009). *Misconceptions in Chemistry (Addresing Perceptions in Chemical Education)*. Sense Publisher. https://doi.org/10.1007/978-3-540-70989-3_2

Borich, G. D. (1994). *Observation Skills for Effective Teaching*. Macmilan Publishing Company.

Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. Springer. https://doi.org/10.1007/978-3-319-15347-6_300893

Braun, I., & Graulich, N. (2024). Exploring diversity: student's (un-)productive use of resonance in organic chemistry tasks through the lens of the coordination class theory. *Chemistry Education Research and Practice*. https://doi.org/https://doi.org/10.1039/D3RP00298E

Cao, C., & Meng, Q. (2022). A systematic review of predictors of international students' cross-cultural adjustment in China: current knowledge and agenda for future research. *Asia Pacific Education Review*, *23*(1), 45–67. https://doi.org/10.1007/s12564-021-09700-1

Carle, M. S., Visser, R., & Flynn, A. B. (2020). Evaluating students' learning gains, strategies, and errors using OrgChem101's module: organic mechanisms—mastering the arrows. *Chemistry Education Research and Practice*, *21*(2), 582–596. https://doi.org/https://doi.org/10.1039/C9RP00274J

Creswell, J. W. (2012). *Educational Research (Planning, Conducting and Evaluation Quantitative and Qualitative Research)* (Fourth). Pearson Education.

Dacosta, M., Sudirga, S. K., & Muksin, I. K. (2017). Perbandingan Kandungan Minyak Atsiri Tanaman Sereh Wangi (Cymbopogon Nardus L. Rendle) Yang Ditanam Di Lokasi Berbeda. *Simbiosis*, *1*, 25.

https://doi.org/10.24843/jsimbiosis.2017.v05.i01.p06

Damianakis, T., Barrett, B., Archer-Kuhn, B., Samson, P. L., Matin, S., & Ahern, C. (2020). Transformative learning in graduate education: masters of social work students' experiences of personal and professional learning. *Studies in Higher Education*, *45*(9), 2011–2029. https://doi.org/10.1080/03075079.2019.1650735

DeWitte, M. (2022). *Gen Z are not 'coddled.' They are highly collaborative, self-reliant and pragmatic, according to new Stanford-affiliated research*. Stanford News.

Dick, W., Carey, L., & Carey, J. O. (2015). *The Systematic Design of Instruction* (6th ed.). Pearson.

Dood, A. J., & Watts, F. M. (2022). Mechanistic reasoning in organic chemistry: A scoping review of how students describe and explain mechanisms in the chemistry education research literature. *Journal of Chemical Education*, *99*(8), 2864–2876.

Du, X., Zhang, L., Hung, J. L., Li, H., Tang, H., & Xie, Y. (2022). Understand group interaction and cognitive state in online collaborative problem solving: leveraging brain-to-brain synchrony data. *International Journal of Educational Technology in Higher Education*, *19*(1). https://doi.org/10.1186/s41239-022-00356-4

Easa, E., & Blonder, R. (2024). Fostering inclusive learning: customized kits in chemistry education and their influence on self-efficacy, attitudes and achievements. *Chemistry Education Research and Practice*.

Espinosa, A. A., Monterola, S. L. C., & Punzalan, A. E. (2013). Career-oriented performance tasks: Effects on students' interest in Chemistry. *Asia-Pacific Forum on Science Learning and Teaching*, *14*(2).

Frey, R. F., McDaniel, M. A., Bunce, D. M., Cahill, M. J., & Perry, M. D. (2020). Using students' concept-building tendencies to better characterize average-performing student learning and problem-solving approaches in general chemistry. *CBE Life Sciences Education*, *19*(3), 1–17. https://doi.org/10.1187/cbe.19-11-0240

Frost, S. J. H., Yik, B. J., Dood, A. J., Arellano, D. C.-R. de, Fields, K. B., & Raker, J. R. (2023). Evaluating electrophile and nucleophile understanding: a large-scale study of learners' explanations of reaction mechanisms. *Chemistry Education Research and Practice*, *24*(2), 706–722. https://doi.org/https://doi.org/10.1039/D2RP00327A

Gagne, R. M. (1970). *The Conditions of Learning* (2nd ed.). HOLT, REINEHART & WINSTON Inc.

Harefa, N., Sinaga, M., & Silaban, S. (2020). Students perception and interest on chemistry: Learning evaluation integrated quizziz media. *Jurnal Pendidikan Kimia*, *12*(3), 143–150. https://doi.org/10.24114/jpkim.v12i3.21163

Havsteen-Franklin, D., Cooper, J., & Anas, S. (2023). Developing a logic model to support creative education and wellbeing in higher education. *Cogent Education*, *10*(1). https://doi.org/10.1080/2331186X.2023.2214877

Helix, M. R., Blackford, K. B., Firestein, Z. M., Greenbaum, Julia C. Gibson, K., & Baranger, A. M. (2022). Characterization of student problem solving and development of a general workflow for predicting organic reactivity. *Chemistry Education Research and Practice*, *23*(4), 844–875. https://doi.org/https://doi.org/10.1039/D1RP00194A

Hunter, K. H., Rodriguez, J. M. G., & Becker, N. M. (2021). Making sense of sensemaking: Using the sensemaking epistemic game to investigate student discourse during a collaborative gas law activity. *Chemistry Education Research and Practice*, *22*(2), 328–346.

https://doi.org/10.1039/d0rp00290a

Keiner, L., & Graulich, N. (2021). Beyond the beaker: Students' use of a scaffold to connect observations with the particle level in the organic chemistry laboratory. *Chemistry Education Research and Practice*, *22*(1), 146–163. https://doi.org/10.1039/d0rp00206b

King, D. (2012). New perspectives on context-based chemistry education: using a dialectical sociocultural approach to view teaching and learning. *Studies in Science Education*, *48*(1), 51–87. https://doi.org/10.1080/03057267.2012.655037

Kwarikunda, D., Schiefele, U., Ssenyonga, J., & Muwonge, C. M. (2020). The Relationship between Motivation for, and Interest in, Learning Physics among Lower Secondary School Students in Uganda. *African Journal of Research in Mathematics, Science and Technology Education*, *24*(3), 435–446. https://doi.org/10.1080/18117295.2020.1841961

Kwarikunda, D., Schiefele, U., Ssenyonga, J., & Muwonge, C. M. (2021). Secondary school students' motivation profiles for physics learning: Relations with cognitive learning strategies, gender, attitudes and individual interest. *African Journal of Research in Mathematics, Science and Technology Education*, *25*(2), 197–210.

Kyriazos, T. A., & Stalikas, A. (2018). Applied Psychometrics: The Steps of Scale Development and Standardization Process. *Psychology*, *09*(11), 2531–2560. https://doi.org/10.4236/psych.2018.911145

Lin, H. shyang, Hong, Z. R., & Chen, Y. C. (2013). Exploring the Development of College Students' Situational Interest in Learning Science. *International Journal of Science Education*, *35*(13), 2152–2173. https://doi.org/10.1080/09500693.2013.818261

Locatelli, S. W., & Davidowitz, B. (2021). Using metavisualization to revise an explanatory model regarding a chemical reaction between ions. *Chemistry Education Research and Practice*, *22*(2), 382–395. https://doi.org/10.1039/d0rp00339e

Mattox, T. M., Pham, A. L., Connolly, M. D., Klivansky, L. M., Dhall, R., & Urban, J. J. (2023). Performing Hazard Analyses and Setting Triggers for Reevaluation in Lab-Scale Chemical Reactions. *Journal of Chemical Education*, *100*(3), 1219–1226. https://doi.org/10.1021/acs.jchemed.3c00017

Mezirow, J. (1997). Transformative Learning: Theory to Practice. *New Directions for Adult and Continuing Education*, *1997*(74), 5–12. https://doi.org/10.1002/ace.7401

Milutinović, V. (2024). Unlocking the code: Exploring predictors of future interest in learning computer programming among primary school boys and girls. *International Journal of Human–Computer Interaction*, 1–18.

Mumba, F., Banda, A., & Chabalengula, V. M. (2018). Junior High School Pre-service Science Teachers' Familiarity, Conceptual Understanding and Interest in Electrochemistry. *African Journal of Research in Mathematics, Science and Technology Education*, *22*(2), 149–161. https://doi.org/10.1080/18117295.2018.1475282

Muntholib, D., Mayangsari, J., Pratiwi, Y. N., Muchson, D., Joharmawan, R., Yahmin, D., & Rahayu, S. (2018). *Development of Simple Multiple-Choice Diagnostic Test of Acid-Base Concepts to Identify Studentsr Alternative Conceptions*. *January*. https://doi.org/10.2991/icomse-17.2018.45

NGSS. (2013). *Next Generation Science Standards: For States, By States*. National Academies Press.

Nur Azizah, R. R., Rahmi, E., & Herman, M. (2022). Pengembangan Media Pembelajaran Teka-Teki Kimia (Tatik) Berbasis Android Pada Materi Reaksi Reduksi Dan Oksidasi Kelas X Di Sma N

1 Koto Baru. *Jurnal Education and Development*, *11*(1), 53–59. https://doi.org/10.37081/ed.v11i1.4235

Obreja, D. M. (2024). When Stories Turn Institutional: How TikTok Users Legitimate the Algorithmic Sensemaking. *Social Media and Society*, *10*(1). https://doi.org/10.1177/20563051231224114

Parobek, A. P., Chaffin, P. M., & Towns, M. H. (2021). Location-thinking, value-thinking, and graphical forms: combining analytical frameworks to analyze inferences made by students when interpreting the points and trends on a reaction coordinate diagram. *Chemistry Education Research and Practice*, *22*(3), 697–714. https://doi.org/https://doi.org/10.1039/D1RP00037C

Phuong Dung, P. T., Minh An, H., Huy, P. Q., & Dinh Quy, N. Le. (2023). Understanding the startup's intention of digital marketing's learners: An application of the theory of planned behavior (TPB) and technology acceptance method (TAM). *Cogent Business and Management*, *10*(2). https://doi.org/10.1080/23311975.2023.2219415

Prameswari, N. S., Cahyono, A., Subiyantoro, S., & Haryanto, E. (2024). Visual literacy study: influence of Instagram on interest in learning photography and its relation to gender. *Media Practice and Education*, *25*(3), 237–249.

Prayitno, H. J., Kusmanto, H., Nasucha, Y., Rahmawati, L. E., Jamaluddin, N., Samsuddin, S., & Ilma, A. A. (2019). The Politeness Comments on The Indonesian President Jokowi Instagram Official Account Viewed From Politico Pragmatics and The Character Education Orientation in The Disruption Era. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, *1*(2), 52–71. https://doi.org/10.23917/ijolae.v1i2.8785

Rahiman, H. U., & Kodikal, R. (2024). Revolutionizing education: Artificial intelligence empowered learning in higher education. *Cogent Education*, *11*(1). https://doi.org/10.1080/2331186X.2023.2293431

Rajiani, I., Prayitno, H. J., Kot, S., Ismail, N., & Iswarani, W. P. (2023). Developing Local Education Content Supplementary Textbook Innovation by Referencing to Women in Floating Market. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, *5*(2), 136–150.

Recuero, R. (2024). The Platformization of Violence: Toward a Concept of Discursive Toxicity on Social Media. *Social Media and Society*, *10*(1). https://doi.org/10.1177/20563051231224264

Rosalina Rawa, N., & Sutawidjaja, A. (2016). Pengembangan Perangkat Pembelajaran Berbasis Model Learning Cycle-7E Pada Materi Trigonometri Untuk Meningkatkan Kemampuan Koneksi Matematis Siswa. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *1*(6), 1042–1055.

Rui, R., Lim, X., Ang, A. S., Fung, F. M., Kong, L., Wing, C., & Road, K. R. (2017). Application of Social Media in Chemistry Education : Incorporating Instagram and Snapchat in Laboratory Teaching. *ACS Symposium Series*, 193–195.

Schweder, S., & Raufelder, D. (2021). Interest, flow and learning strategies how the learning context affects the moderating function of flow. *Journal of Educational Research*, *114*(2), 196–209. https://doi.org/10.1080/00220671.2021.1887066

Silva, A. R., Matos, S., Gabriel, R., Moura Arroz, A., Sousa, D., Piasentin, F., & Amorim, I. R. (2024). The Field Guide audio series: mobile learning using place-based and inquiry-led approaches to promote adolescents' interest in nature. *Environmental Education Research*, *30*(6), 941–963.

Singer, S. R., & Nielsen, N. R. (2012). *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. The National Academies Press.

Smith, A., McConnell, L., Iyer, P., Allman-Farinelli, M., & Chen, J. (2024). Co-designing assessment tasks with students in tertiary education: a scoping review of the literature. *Assessment and Evaluation in Higher Education*, *0*(0), 1–20. https://doi.org/10.1080/02602938.2024.2376648

Sofnidar, S., & Yuliana, R. (2018). Pengembangan Media Melalui Aplikasi Adobe Flash Dan Photoshop Berbasis Pendekatan Saintifik. *Jurnal Gentala Pendidikan Dasar*, *3*(2), 257–275. https://doi.org/10.22437/gentala.v3i2.6761

Suja, I. W., Redhana, I. W., & Sudria, I. B. N. (2020). Mental Model of Prospective Teachers on Structure and Properties Correlation of Organic Compounds. *Journal of Physics: Conference Series*, *1503*(1). https://doi.org/10.1088/1742-6596/1503/1/012034

Sumintono, B., & Widhiarso, W. (2015). *Aplikasi Pemodelan Rasch Pada Assessment Pendidikan*. Penerbit Trim Komunikata.

Sunyono, S. (2018). Mental models of atomic structure concepts of 11th grade chemistry students. *Asia-Pacific Forum on Science Learning and Teaching*, *19*(1), 1–21.

Susanti, S., Putra, R. P., Agustina, R. D., Quy, N. P., Siregar, H. S., & Silva, J. da. (2023). Exploring the Educational Landscape: The Impact of Post-Covid Online Learning on Physics Education Undergraduates' Academic Engagement and Achievement. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, *6*(1), 86–104. https://doi.org/10.23917/ijolae.v6i1.22179

Taylor, S., & Sobel, D. (2011). *Culturally Responsive Pedagogy: Teaching Like Our Students' Lives Matter*. Emerald Group Publishing LImited.

Trilling, B., & Fadel, C. (2009). *21st Century Skills: Learning For Life In Our Times*. Jossey-Bass.

United-Nation. (2023). SDGs Report 2023. In *The Sustainable development Goals Report 2023: Special Edition*.

van Dinther, R., de Putter, L., & Pepin, B. (2023). Features of Immersive Virtual Reality to Support Meaningful Chemistry Education. *Journal of Chemical Education*, *100*(4), 1537–1546. https://doi.org/10.1021/acs.jchemed.2c01069

Wackerly, J. W. (2021). Abductive Reasoning in Organic Chemistry. *Journal of Chemical Education*, *98*(9), 2746–2750. https://doi.org/10.1021/acs.jchemed.1c00295

Wang, Y., & Lewis, S. E. (2020). Analytical chemistry students' explanatory statements in the context of their corresponding lecture. *Chemistry Education Research and Practice*, *21*(4), 1183–1198. https://doi.org/10.1039/d0rp00063a

Winarti, A., Almubarak, A., & Saadi, P. (2022). Pengembangan Bahan Ajar Transformative Learning Berbasis Gaya Belajar untuk Meningkatkan Kemandirian Belajar di Era Covid-19. *Prosiding Smeinar Nasional Lingkungan Lahan Basah*, *7*(1), 74–82.

Wisudawati, A. W., Barke, H. D., Lemma, A., & Agung, S. (2022). Students' and teachers' perceptions for composition of ionic compounds. *Chemistry Teacher International*, *4*(3), 221–230. https://doi.org/10.1515/cti-2021-0032

Wright, B. D., & Masters, G. N. (1982). *Rating scale analysis*. MESA Press.