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Development of Teaching Modules Based on Technological Pedagogical Content Knowledge and Culturally Responsive Transformative Teaching on the Topic of Chemical Bonding

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Abstract

This research aimed to produce feasible and practical teaching modules on grade X chemical bonding topic based on Technological Pedagogical Content Knowledge (TPACK) and Culturally Responsive Transformative Teaching (CRTT). It is a Research and Development (R&D) using the five-step Borg and Gall model. 36 students from class X at SMAN 1 Narmada participated in this study's limited trial. Data collection techniques used validation instruments and practicality questionnaires. Aiken's V index which measures the validity of six aspects including aspects of content feasibility, aspects of suitability for the learning model, aspects of cultural suitability, language, assessment, and completeness of attachments, obtained an average value of V = 0,89 which indicates that the TPACK and CRTT-based teaching module is classified as very valid. The feasibility of the validation results of the teaching module includes six aspects of assessment, with the acquisition of scores in each aspect including; the aspects of content eligibility, suitability with the learning model, cultural suitability, language, assessment, and completeness of attachments obtained an average score of 0.95 consecutively; 0,83; 0,91; 0,83; 0,83; and 1.00. Meanwhile, the practicality test of teaching modules based on teacher responses on the aspects of ease, practicality, attractiveness and benefits of teaching obtained an average practicality of 90% classified as very practical, with four aspects of assessment by teachers, namely ease of use, practicality, attractiveness, and benefits that obtained an average score of 84%; 92%; 92%; and 93% respectively. Students' responses on the aspects of presentation, ease of use and benefits of learning devices obtained an average practicality of 83% classified as practical, with an assessment of three aspects, namely media presentation, ease of use of media, and benefits, the average practicality of each was 83%; 82%; and 84%. Thus, it can be concluded that the TPACK and CRTT-based teaching module on the topic of chemical bonding class X SMAN developed is feasible to use in terms of validity and practicality. TPACK and CRTT-based development research is more carried out on the development of e-modules, LKPD for students has not developed many TPACK-based and CRTT-based teaching modules. In addition, previous research has integrated PBL, discovery learning, and PjBL models in developing a teaching material on chemical equilibrium, colloid, and others using 4D and ADDIE development models.

Keywords: Research and Development, Teaching Module, TPACK, CRTT, Chemical Bonding

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INTRODUCTION

Chemistry is one of the main subjects at the senior high school level. The purpose of chemistry courses is to develop students' critical thinking abilities and to help them understand chemical principles so they can solve challenges in technology and daily life (Aminah et al., 2024). Furthermore, chemistry courses are complicated, understanding the content needs an

affective conceptual conceptual understanding and critical thinking skills (Surachman et al., 2014). Chemical bonds are the forces of attraction between atoms or molecules, so that the state becomes more stable (Constable & Housecroft, 2020). This is true with the characteristics of chemistry which is abstract, simplification of the actual situation (Adawiyah et al., 2021). Students sometimes struggle to relate to relate concepts of chemical bonding to application in life as a result. Students can understand chemical topics less if they are not provided with sufficient textbox and are taught using methods that are not helpful to their habits of learning (Priliyanti et al., 2021).

The teaching module is one of the chemical learning resources in the Merdeka Curriculum (Farwati et al., 2022). One kind of teaching tool is the teaching tool is the teaching module, which has a lesson plan to guide the learning process and achieve goals for learning (Nuraini et al., 2023). Teachers and students may explore the concept of independence in the learning process with the help of the Merdeka Curriculum teaching module. Teaching modules represent an important part in aiding teachers to organize the learning process. Teaching modules are usually composed of three main parts: (1) General information, which includes module identify, initial competencies, Pancasila learner profile, facilities and equipment, student targets, and learning models, (2) The core component, which include learning goals, meaningful comprehension, triggering questions, learning activities, assessment, enrichment, and remedial, (3) Appendix, which include student worksheet, teacher and student reading materials, glossary, and bibliography (Mulyani & Insani, 2023). Using interactive and collaborative learning models and approaches is one of the characteristics of Merdeka Curriculum's teaching module (Ghafara et al., 2023).

TPACK and CRTT represent two interactive and collaborative learning models and approaches (Triwahyudi et al., 2021; Rahmawati et al., 2023). Technological, pedagogical, and content knowledge are the three primary components of TPACK (Technological Pedagogical Content Knowledge), an activity that analyzes the relationship knowledge and the use of technology in learning activities (Hanik et al., 2022). Meanwhile, one of the learning approaches that integrates students' experiences or cultural backgrounds with the learning topics is called Culturally Responsive Transformative Teaching (CRTT), which aims to provide more meaningful learning (Agung et al., 2022). The five learning syntaxes that compose the basis of the CRTT model are self-identification, cultural understanding, cooperation, critical thinking, and transformational interpretation. These skills can promote tolerance and respect for others, as well as improve their ability for critical thinking and improve their motivation for learning (Rahmawati et al., 2020;Adawiyah et al., 2022). However, according to Damayanti, et al (2017) science education in schools still focuses on subject content in general and has not integrated natural science with scientific science (Zulfa et al., 2024). This disorder is put on by teachers' challenges creating lesson plans, their lack of teachers still lacks an understanding of how technology and ethnoscience are integrated into science education, especially in the topic of chemistry, due to an inability of training in developing technology and ethnoscience-based teaching modules (Alfiana & Fathoni, 2022; Mairisiska et al., 2014). The TPACK approach can improve student understanding, help teachers integrate technology, provide new challenges for students, help teachers achieve learning goals, and facilitate the simplification of content (Triwahyudi et al., 2021; Nuraini et al., 2023). Meanwhile, the CRTT model in chemistry learning is effective in improving students' critical thinking skills, scientific attitudes, and soft skills, because with the CRTT model students will learn to recognize cultural heritage from various ethnicities, build meaningful relationships between students, and create a learning environment that is relevant to culture (Rahmawati et al., 2020; Adawiyah et al., 2022; Lusida et al., 2024; Whatoni et al., 2024).

Culture-based learning in modules related to chemical bonding materials, namely Lombok songket woven fabric crafts that pay attention to transformative aspects of culture.

Woven fabric crafts include several manufacturing processes, ranging from preparation for yarn making, preparation of yarn dyes, yarn dyeing process, and drying. However, the integration of songket woven fabric handicrafts into chemical bonding materials is focused on the dyeing process of woven yarn, because it involves the occurrence of ionic bonds and covalent bonds between woven yarn and dyes and color binders (mordan) used by craftsmen, in this case betel lime ($Ca(OH)_2$) and alum ($Al_2(SO_4)_3$). Through the integration of songket woven fabric crafts into chemical bonding materials, there are several expected learning objectives, namely a) students are able to explain the concept of chemical bonds in the dyeing process of Lombok songket woven yarn, b) students are able to distinguish ion bonds and covalent bonds in the dyeing process of Lombok songket woven yarn, and c) students are able to conclude the occurrence of ionic bonds and covalent bonds in the dyeing process of Lombok songket woven yarn.

The goal of study of culture-based learning in science lessons is to develop science literacy of students and critical thinking abilities, and every area has its own culture (Suryani et al., 2023; Jannah et al., 2022; Ma & Austria, 2023). None has ever been done for developing TPACK and CRTT-based training modules on the topic of chemical bonding in Sasak traditional songket woven cloth crafts, under the context of integrating technological advances and cultural awareness in the surrounding environment, this research is necessary to support teachers to improve the effectiveness of chemistry lessons and offer students meaningful learning experiences. Thus, the goal of this study is to develop feasible and practical teaching modules on class X chemical bonding topic using TPACK and CRTT.

METHOD

The research conducted is Research and Development (R&D). The methodical study of designing and developing a product for use in schools, be it media, models, methods of learning strategies has been called development research (Usmeldi & Amini, 2020). This research used the Borg and Gall development model research methodology, which consist of five steps: preliminary study, product planning, product development, product trials, and revision of product implementation results (Gall & Borg, 2003; Surachman et al., 2014).

The subject in this research were expert validators namely chemistry education lecturers FKIP, University of Mataram, chemistry subject teachers SMAN 1 Narmada and SMAN 1 Keruak and 36 class X-I students at SMAN 1 Narmada to determine the validity and practicality of the products developed. According to Baley (2011) statistics, the minimum number of samples in development research is 30. So that as many as 36 students who were used as a sample were included in the adequate category and exceeded the number of samples in general. Figure 1 shows the development procedure used in the research with the Borg and Gall model.

The first step of research, which is the preliminary study step, tries to collect data about the conditions, realities, and issues surrounding chemistry education. To identify the needs, the preliminary study's chemistry teachers in class X were observed and interviews of the SMAN 1 Narmada's chemistry teaching modules. Additionally, local were interviews about the local wisdom expressed, especially in reference to the songket woven fabric craft in Sukarara Village, Central Lombok Regency, West Nusa Tenggara Province. Furthermore, an analysis of the chemical bonding content included in the TPACK and CRTT-based training modules was done at this phase.

The steps involved in the product planning step include creating a strategy for the research needs, starting with the research subject, organizing the questionnaire that will be used, organizing the goals and question of the study, organizing the research design, organizing the research testing procedures and the data analysis. Using the Canva application, product design was created into a storyboard. Visual Paradigm Online used to create flipbook reading content.

During the product development step, instructional modules were developed and the validity of the preliminary product development findings was evaluated by qualified validators.

Product Development

Product development is conducted by making teaching modules as follows the results at the product planning step. In addition, the preparation of the instructional module's components was one at this step. The application that is used is chosen after taking into factor the ease the tools are to use. The prototype 1 teaching module was completed at this step.

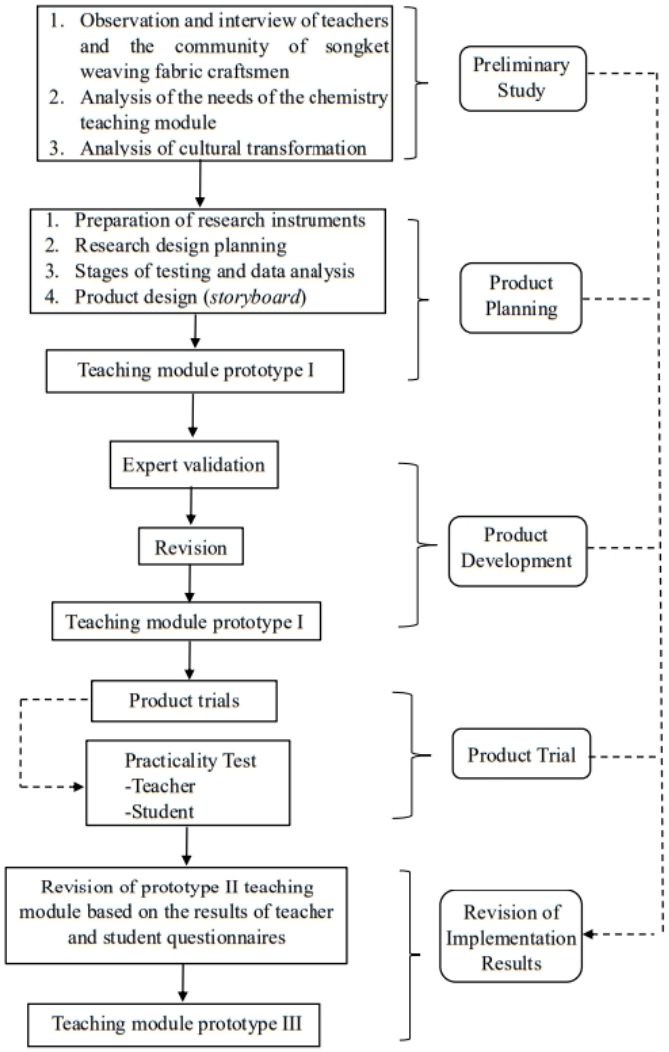

Figure 1. The Product Development Steps

Product Validation

Expert validators, namely chemistry education lecturers FKIP Unram, chemistry teachers SMAN 1 Narmada, and SMAN 1 Keruak, carried out the product validation. A validation instrument sheet with specific assessments based on elements of the test's validity was used educational resources and materials. There are six aspects that become the standard of module scoring including aspects of content feasibility, aspects of suitability for he learning model, aspects of cultural suitability, language aspects, assessment aspects and completeness of attachments. The instruments used in this study include interview sheets, expert validation sheets, teacher and student questionnaires. The interview sheet was used to collect data related to chemistry learning and songket woven fabric crafts. Meanwhile, the expert validation sheet was used to obtain an assessment for the validity of the prototype 1 teaching module and the

teacher and student questionnaires were used to obtain as assessment of the practicality of the teaching modules and learning media that had been implemented.

Product Trial

After being validated, the teaching module is improved by following the expert validators' comments and suggestions and then the valid teaching module is tested in one class X SMAN 1 Narmada. Then a teacher response questionnaire was filled in to identify the practicality of using teaching modules based on TPACK and CRTT and filling in student response questionnaires to identify the practicality of using learning media in teaching modules.

Data Analysis Techniques

The data analysis technique used in this study is quantitative descriptive analysis. Quantitative descriptive or descriptive statistics is a statistical method that involves organizing, summarizing, and presenting data so that it becomes useful information (Suharsono et al., 2023).Data analysis techniques include testing the validity and practicality of teaching modules.

Data Analysis of Expert Validation

Analyze expert validation data using Aiken's V index the following formula:

$$V = \frac{\Sigma_s}{n(c-1)}$$

Description:

V = V Aiken's validity index
s = r-lo
r = The score given by the validator
lo = Lowest validity score
n = Number of validators
c = Highest validity score

The Aiken's V score obtained was confronted with the validity criteria in Table 1 to determine the feasibility of the developed module.

Table 1. Aiken's Index Categories

Scoring Results	Category
0.00-0.10	Very less valid
0.11-0.30	Less valid
0.31-0.50	Valid enough
0.51-0.80	Valid
0.81-1.00	Very valid

(Aiken's, 1985; Camelia et al., 2023)

Aiken's V index equation is used to calculate the results of expert validation from three validators. The expert validation process is carried out before the product trial stage, with the aim of producing a prototype 2 teaching module. At the expert validation stage, instruments in the form of validation sheets and prototype 1 teaching modules were given to the three validators who assessed six aspects of the teaching module, including aspects of content eligibility, suitability with the learning model, suitability with culture, language, assessment, and completeness of attachments with an assessment scale of 1 to 5 with criteria 1 = very invalid, 2 = invalid, 3 = less valid, 4 = valid, and 5 = very valid. After providing an assessment, validators can provide suggestions for improvements to the teaching module before implementation.

Data Analysis of Teaching Module Practicality

The developed product can be said to be practical if teachers and students can use teaching modules and learning media in teaching modules easily. The practicality of the teaching module is measured by a Likert scale. Analysis of practicality using the percentage formula according to Sugiyono (2018).

$$P = \frac{F}{N} \text{ x } 100\%$$

Description:
P = Practicality percentage
F = Score acquisition
N = Minimum score

After the percentage value of practicality is obtained, grouping is cried out according to the criteria in Table 2.

Table 2. Criteria for Interpreting the Practicality Score

Scoring Acquisition (%)	Category
0-39	Not practical
40-54	Less practical
55-69	Practical enough
70-84	Practical
85-100	Very practical

(Sugiyono, 2018)

The use of the Likert scale with a combination of equations to calculate the practicality score of the teaching module as a result of the implementation. The Likert scale with modified alternative answers is 1 = strongly disagree, 2 = disagree, 3 = disagree, 4 = agree, and 5 = strongly agree on the questionnaire given to teachers and students. The assessment of practicality by teachers of teaching modules refers to four aspects, namely ease of use, practicality, attractiveness, and benefits. The assessment of the practicality of learning media in the teaching module by students refers to three aspects, namely presentation, ease of use, and benefits of Wordwall and flipbook learning media.

RESULTS AND DISCUSSION

The purpose of this development research is to produce teaching modules based on Technological Pedagogical Content Knowledge (TPACK) and Culturally Responsive Transformative Teaching (CRTT). The development of TPACK and CRTT-based teaching modules on the topic of chemical bonding was carried out in five steps as follows:

Preliminary Study

Chemistry teachers' use of the Merdeka Teaching Platform teaching module, Erlangga chemistry textbook and student worksheet as learning resources, and the Problem Based Learning (PBL) learning model with a scientific approach. The results of a study by Ramdoniati, et al (2018) indicate that PBL-based chemistry teaching materials are good enough to develop students' metacognitive skills in chemical materials, but that PBL-based teaching materials have not produced those maximum results. However, student activeness in learning is not optimal, so student still need to be directed by varying learning models and approaches. Based on the results of interviews with songket weaving crafter, information was found in the process of coloring songket woven fabrics still using natural materials and using synthetic dyes to meet consumer needs.

The teacher's ability to teach and learn is impacted by the lack of teaching modules and teacher resources related to learning models that integrate content to students' cultural backgrounds and integrate technology into the learning process. As a result, researchers developed TPACK and CRTT-based teaching modules that are needed for chemistry learning. Teaching modules are important to be developed to provide learning tools, increase teacher and student participation in the learning process, so that learning activities become more effective and efficient (Herliana et al., 2023).

Product Planning

The learning goals, learning materials, learning strategies, learning activities, learning resources, assessment tools, and teaching module development were all taken into consideration when designing TPACK and CRTT-based teaching modules during the planning step. Furthermore, by integrating Sasak songket woven fabric crafts and technology into the teaching process, the development of teaching modules also takes note of the specifications of TPACK and CRTT-based teaching modules on class X chemical bonding contents. The teaching module design contains teaching modules components, such as: (1) General information which includes module identity, initial competence, Pancasila learner profile, facilities and equipment, target students, learning model, (2) Core components which include learning objectives, meaningful understanding, triggering questions, learning activities, assessment, enrichment and remedial, (3) Appendix which includes student worksheet, teacher and student reading materials, glossary, and bibliography. The teaching module is designed with A4 size (21 cm x 29,7 cm) with white and blue base colors in the header and footer. Module size and components are aspects that need to be considered in developing a teaching material (Muldiyana et al., 2018).

Product Development

The purpose of the development step is to produce the prototype 1 teaching module. After development, a validity test is conducted on the teaching module to verify that it is ready to use in the classroom. The following is the appearance of the prototype 1 teaching module.

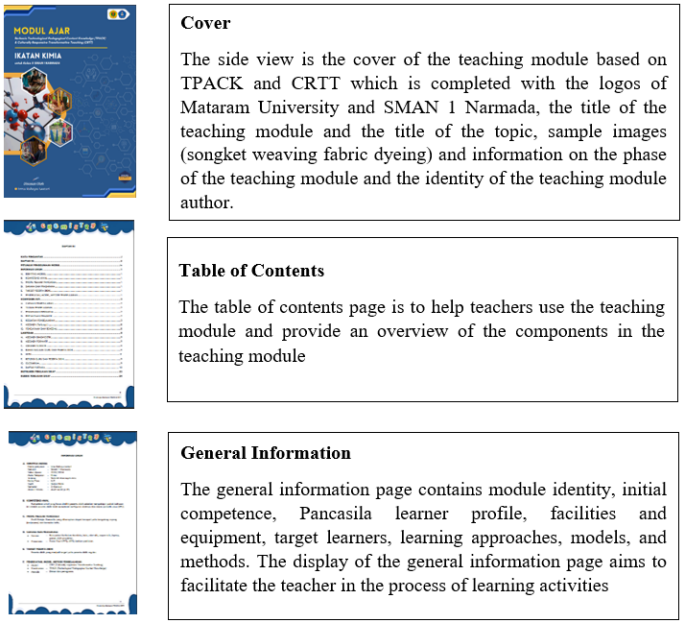

Figure 1. Prototype 1 Teaching Module

Results of Validity Test

The validity test considers six aspects of assessment: aspects of content feasibility, aspects of suitability for the learning model, aspects of cultural suitability, language, assessment, and completeness of attachment.

Table 3. Results of Expert Validation Test

Aspects assessed	Average score	Category
Content feasibility	0.95	Very valid
Suitability for the learning model	0.83	Very valid
Cultural suitability	0.91	Very valid
Language	0.83	Very valid
Assessment	0.83	Very valid
Completeness of attachments	1.00	Very valid
Average	**0.89**	**Very valid**

Based on Table 3, it can be concluded that the developed TPACK and CRTT-based teaching modules scored a validity value of 0,89 from three validators, putting them in the very valid category. The highest average assessment score was obtained in the aspects of attachment completeness and content feasibility, because these two aspects include several assessment indicators, namely the completeness of the teaching module components, such as module identity, P5 description, approaches, models, and learning methods, CP descriptions, TP, learning activity tables, assessment details, to attachment components such as LKPD to assessment instruments. However, in contrast to the assessment of language aspects with three assessment indicators, namely the suitability of language and sentence use, language style with target users, and the use of clear and unambiguous language, this has received attention from validators because writing rules still need to be improved in several parts, such as the use of capital letters, punctuation, consistency of writing, writing compound formulas and the use of foreign terms. Teaching materials used in learning activities significantly affect student motivation and interest in learning, so that the teaching materials used have the integrity of the content of the material as well as supporting components that can generate student understanding (Supriyono, 2018).

Product Trial

After the teaching module was modified based on comments from validators, the product trial step was completed. At the step, a prototype 2 teaching module was produced and tried in small sample of 36 students of class X-I at SMAN 1 Narmada.

Results of the Practicality Test

Upon finishing both teachers and students' response questionnaires, the practicality test aims to determine the level of practicality of the evaluated instructional module. Four components of assessment are included in the teacher response questionnaire: benefits, ease of uses, practicality of the module, and attractiveness. While three components of assessment are included in the student response questionnaires about the usefulness of learning media: benefits, easy access to us, and presentational features. Tables 4 and 5 display the practicality test findings.

Table 4. Results of Practicality Test by Teacher

Aspects	Average practicality (%)	Category
Ease of use	84	Practical
Practicality	92	Very practical
Attractiveness	92	Very practical
Benefits	93	Very practical
Average	**90**	**Very practical**

Based on Tables 4 and 5, the results of the teaching module practicality test obtained an average score of 90% and 83%, which indicated that the teaching module was classified as very practical. The teacher response questionnaire score was in the range of 85% < x < 100%.

The results of the practicality test by teachers in four aspects of assessment obtained the highest score in the benefit aspect, which is 93%, this is because the TPACK and CRTT-based teaching modules developed can help teachers in providing teaching and learning experiences for students through contextual learning with the integration of cultures that have been known by students into learning materials. Meanwhile, the aspect of ease of use obtained an average of 83%, because teachers have never used TPACK-based and CRTT-based teaching modules before but use PBL-based teaching modules, so teachers experience little difficulty in implementing teaching modules in the classroom. The results of the Wordwall and flipbook learning media practicality test, which were based on student response questionnaires, included the practical category because the score was in the range of 70% < x < 84%. The aspect of assessing the benefits of learning media obtained the highest score because through integrated learning media with culture and technology, students gained new learning experiences, helped increase learning motivation, and practiced their skills in operating technology as a learning resource. In terms of ease of use, students have a little difficulty in using flipbook and Wordwall media because students have never used both media, so this aspect is not too high. The point to which a module is user friendly, attractive to users, and effective in developing their curiosity in learning through modules is referred to as its practicality (Sari et al., 2018; Yerimadesi et al., 2022).

Table 5. Results of Students' Practicality Test of Learning Media

Aspects	Average practicality (%)	Category
Presentation	83	Practical
Ease of use	82	Practical
Benefits	84	Practical
Average	**83**	**Practical**

Revision of Product Implementation Results

Therefore, to improve the teaching module prototype 2, revisions were made based on the responses to questionnaires given to teacher and students. These revisions were made in response to the trial results of the teaching module. At this step, prototype 3 teaching modules were produced. The teaching module's revised sections include: revisions to the flipbook reading materials, instructions for using the Wordwall platform and flipbook reading materials, and a Wordwall platform display for assessment. Some components of the developed teaching module need to be improved due to weaknesses in the first product trial results. In order to perfect the product, a limited trial is followed by the revision step (Irmita, 2018).

Advantages of TPACK and CRTT-based teaching modules that have been developed compared to research Izzania, et al (2024) dan Nuraini, et al (2023) That is, contributing to improving chemistry learning in schools through the integration of technology and culture, helping teachers implement contextual chemistry learning, so as to provide meaningful learning and in line with the goals of 21st century education. The shortcomings of the teaching module developed are that the trial was only limited to one class X with 36 students of SMAN 1 Narmada, adjusting to the stages of Borg and Gall development which was carried out in only one cycle. The challenges faced during the validation and trial process include the factor of long validation time, so that it has an impact on the improvement time of teaching modules and limited trials in schools. Future research should pay more attention to the validation time of the product being developed, and conduct trials on a wide scale by paying attention to the development stages.

CONCLUSION

Teaching modules based on Technological Pedagogical Content Knowledge (TPACK) and Culturally Responsive Transformative Teaching (CRTT) on the topic of chemical bonding have been developed with the Borg and Gall model, namely from the preliminary study step,

product planning, product development, product trials, and revision of product implementation result are feasible to use in terms of validity and practicality. Based on the research results obtained that the average value of validation for all aspects of the assessment is 0,89 classified as a very valid category and the average value of the practicality level of the teaching module from the teacher response 0f 90% including very practical category, as well as the practicality of Wordwall and flipbook learning media based on student responses of 83% including practical category.

RECOMMENDATION

Due to time constraints, this development research was only able to complete one development cycle rather than all ten. It is anticipated that research will continue until the dissemination step. Furthermore, this research only looked at validity and practicality testing. The effectiveness test of the teaching module can be improved by further research. This research is expected to help the development of teaching modules based on TPACK and CRTT in the future by paying attention to the integration of technology and student culture into chemistry learning in high school, so that it can make it easier for researchers to develop independent curriculum teaching modules.

REFERENCES

Adawiyah, R., Andayani, Y., & Savalas, L. R. T. (2022). Pengembangan modul kimia etnosains terintegrasi model Culturally Responsive Transformative Teaching (CRTT). *Journal of Classroom Action Research*, *4*(4), 123–128. https://doi.org/10.29303/jcar.v4i4.2395

Adawiyah, R., Laksmiwati, D., Supriadi, S., & Mutiah, M. (2021). Pengembangan E-modul berbasis tiga level representasi pada materi kesetimbangan kimia untuk siswa sekolah menengah atas kelas XI. *Chemistry Education Practice, 4*(3), 262–268. https://doi.org/10.29303/cep.v4i3.2744

Agung, A., Handayani, A. T., Andayani, Y., & Anwar, Y. A. S. (2022). Pengembangan LKPD IPA SMP berbasis etnosains terintegrasi Culturally Responsive Transformative Teaching (CRTT). *Journal of Classroom Action Research*, *4*(4), 131–135. https://doi.org/10.29303/jcar.v4i4.2396

Alfiana, A., & Fathoni, A. (2022). Kesulitan guru dalam menerapkan pembelajaran IPA berbasis etnosains di sekolah dasar. *Jurnal Basicedu*, *6*(4), 5721–5727. https://doi.org/10.31004/basicedu.v6i4.3123

Aminah, Wildan, Loka, I. N., & Muntari. (2024). Pengembangan E-modul kimia materi larutan penyangga berbasis kontekstual pada pembelajaran Daring siswa SMA kelas XI. *Chemistry Education Practice*, *7*(1), 62–68. https://doi.org/10.29303/cep.v7i1.3516

Baley. (2011). *Metode Penelitian Pendidikan*. Bandung: Pustaka Setia.

Camelia, S., Mawardi. M, & Okta Suryani. (2023). Pengembangan bahan ajar untuk menunjang pembelajaran Kurikulum Merdeka pada materi konsep dan dampak pemanasan global fase E SMA/MA. *Jurnal Pendidikan MIPA*, *13*(2), 530–537. https://doi.org/10.37630/jpm.v13i2.1091

Constable, E. C., & Housecroft, C. E. (2020). Chemical bonding: The journey from miniature hooks to density functional theory. *Molecules*, *25*(11), 1–44. https://doi.org/10.3390/molecules25112623

Farwati, R., Metafisika, K., Sari, F. N., Sholeh, M. I., & Kunci, K. (2022). Kesiapan guru kimia menghadapi Kurikulum Merdeka. *Jurnal Al'ilmi*, *11*(2), 7–11.

Ghafara, S. T., Jalinus, N., Ambiyar, A., Waskito, W., & Rizal, F. (2023). Pembelajaran menggunakan TIK dapat meningkatkan literasi peserta didik generasi Z pada Kurikulum Merdeka. *Jurnal SAINTIKOM (Jurnal Sains Manajemen Informatika Dan Komputer)*, *22*(2), 241-251. https://doi.org/10.53513/jis.v22i2.8503

Hanik, E. U., Puspitasari, D., Safitri, E., Firdaus, H. R., Pratiwi, M., & Inayah, R. N. (2022). Integrasi pendekatan TPACK (Technological, Pedagogical, Content Knowledge) guru sekolah dasar SIKL dalam melaksanakan pembelajaran era digital. *JEID: Journal of Educational Integration and Development*, *2*(1), 15–27. https://doi.org/10.55868/jeid.v2i1.97

Herliana, F., Kasli, E., Azhariah, S. K., Mahzum, E., Farhan, A., Nurulwati, N., Syukri, M., & Mohtar, L. E. (2023). Development of guided inquiry based on Blended Learning (GIbBL) teaching module for physics in the independent curriculum. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *9*(2), 273–286. https://doi.org/10.21009/1.09210

Irmita, L. U. (2018). Pengembangan modul pembelajaran kimia menggunakan pendekatn Science, Technology, Engineering and Mathematic (STEM) pada mteri kesetimbangan kimia. *Oribital: Jurnal Pendidikan Kima*, *2*(2), 27–37.

Izzania, R. A., Sumarni, W., & Harjono, H. (2024). Pengembangan E-modul ajar kimia hijau bermuatan etno-STEM berbasis guided inquiry untuk membekali kemampuan berpikir kritis peserta didik. *Jurnal Inovasi Pendidikan Kimia*, *18*(1), 7–16. https://doi.org/10.15294/jipk.v18i1.46536

Jannah, R., Festiyed, F., Yerimadesi, Y., Lufri, L., & Putra, S. (2022). Ethnoscience in learning science: A systematic literature review. *Scientiae Educatia*, *11*(2), 175–184. https://doi.org/10.24235/sc.educatia.v11i2.11488

Lusida, I. A., Pratiwi, D. E., & Novayanti, N. D. (2024). Implementasi pendekatan Culturally Responsive Teaching materi masa sebelum uang ditemukan pada peserta didik kelas IV SDN Pakis V Surabaya. *Indonesian Research Journal on Education*, *4*(1), 174–180.

Ma, S., & Austria, R. S. (2023). Research on influencing factors of teachers' effective teaching ability in higher vocational colleges based on TPACK model. *2023 5th International Conference on Applied Machine Learning (ICAML)*, 336–340. https://doi.org/10.1109/ICAML60083.2023.00069

Mairisiska, T., Sutrisno, S., & Asrial, A. (2014). Pengembangan perangkat pembelajaran berbasis TPACK pada materi sifat koligatif larutan untuk meningkatkan keterampilan berpikir kritis siswa. *Edu-Sains: Jurnal Pendidikan Matematika Dan Ilmu Pengetahuan Alam*, *3*(1), 28-37. https://doi.org/10.22437/jmpmipa.v3i1.1764

Muldiyana, Ibrahim, N., & Muslim, S. (2018). Pengembangan modul cetak pada mata pelajaran produktif teknik komputer dan jaringan di SMK Negeri 2 Watampone. *Jurnal Teknologi Pendidikan*, *20*(1), 43–59. https://doi.org/10.21009/jtp.v20i1.7845

Mulyani, H., & Insani, M. N. (2023). Kompetensi guru sekolah penggerak dalam menyusun modul ajar Kurikulum Merdeka. *Jurnal Lingkar Mutu Pendidikan*, *20*(1), 1–10. https://doi.org/10.54124/jlmp.v20i1.95

Nuraini, N. L. S., Cholifah, P. S., Rini, T. A., Aurelia, D., Sofirin, A., Huzaimah, C., & Nafisah, N. (2023). Pengembangan modul ajar Kurikulum Merdeka berbasis TPACK bagi guru kota Malang. *Jurnal Basicedu*, *7*(6), 3466–3474. https://doi.org/10.31004/basicedu.v7i6.6306

Priliyanti, A., Muderawan, I. W., & Maryam, S. (2021). Analisis kesulitan belajar siswa dalam mempelajari kimia kelas XI. *Jurnal Pendidikan Kimia Undiksha*, *5*(1), 11–18. https://ejournal.undiksha.ac.id/index.php/JJPK

Rahmawati, Y., Mardiah, A., Taylor, E., Taylor, P. C., & Ridwan, A. (2023). Chemistry learning through Culturally Responsive Transformative Teaching (CRTT): Educating Indonesian high school students for cultural sustainability. *Sustainability*, *15*(8), 1–18. https://doi.org/10.3390/su15086925

Rahmawati, Y., Ridwan, A., Faustine, S., & Mawarni, P. C. (2020). Pengembangan soft skills siswa melalui penerapan Culturally Responsive Transformative Teaching (CRTT) dalam pembelajaran kimia. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 86–96. https://doi.org/10.29303/jppipa.v6i1.317

Ramdoniati, N., Muntari, M., & Hadisaputra, S. (2018). Pengembangan bahan ajar kimia berbasis Problem Based Learning untuk meningkatkan keterampilan metakognisi. *Jurnal Penelitian Pendidikan IPA, 5*(1), 27-33. https://doi.org/10.29303/jppipa.v5i1.148

Sari, D. R., Hardeli, & Bayharti. (2018). Development of chemistry triangle oriented module on topic of reaction rate for senior high school level grade XI chemistry learning. *IOP Conference Series: Materials Science and Engineering*, *335*(1), 1–12.

Suharsono, A., Mashuri, M., Wibawati, W., Khusna, H., & Ahsan, M. (2023). Pelatihan pembelajaran statistika untuk peningkatan kompetensi guru matematika di Kabupaten Sumenep. *Sewagati*, *7*(5), 672–681. https://doi.org/10.12962/j26139960.v7i5.542

Supriyono. (2018). Pentingnya media pembelajaran untuk meningkatkan minat belajar siswa SD. *Edustream: Jurnal Pendidikan Dasar*, *11*(1), 43–48. https://doi.org/https://doi.org/10.26740/eds.v2n1.p43-48

Surachman, M., Muntari, & Savalas, L. R. T. (2014). Pengembangan multimedia interaktif berbasis kontekstual untuk meningkatkan penguasaan konsep dan keterampilan berpikir kritis siswa kelas XI pada materi pokok sistem koloid. *Jurnal Pijar MIPA*, *9*(2), 62–67.

Suryani, D., Fajar Sidik, R., Hadi, W. P., Yasir, M., & Sutarja, M. C. (2023). Pengembangan media web mobile learning berbasis etnosains pada materi konduktivitas. *Jurnal Pendidikan IPA*, *12*(1), 1–14. https://doi.org/10.20961/inkuiri.v12i1.64060

Triwahyudi, S., Raden Mattaher Nomor, J., & Jambi, K. (2021). Pengembangan perangkat pembelajaran berbasis TPACK pada materi kimia SMA. *Chempublish Journal*, *6*(1), 46–53. https://doi.org/10.22437/chp.xxx.xxx

Usmeldi, & Amini, R. (2020). The effect of integrated science learning based on local wisdom to increase the students competency. *Journal of Physics: Conference Series*, *1470*(1), 1–7. https://doi.org/10.1088/1742-6596/1470/1/012028

Whatoni, A. S., Anwar, Y. A. S., & Namira, D. (2024). Penerapan pendekatan Culturally Responsive Teaching untuk meningkatkan hasil belajar dan minat belajar kimia peserta didik. *Didaktika: Jurnal Penelitian Tindakan Kelas*, *2*(1), 22–28. https://didaktika.lombokinstitute.com/index.php/

Yerimadesi, Wahyuni, Z. A., Andromeda, Guspatni, Pradipta, A., Khaira, U., & Mareza, A. (2022). Validity and practicality of guided Discovery Learning-based chemistry E-module for class XII high school. *Journal of Physics: Conference Series*, *2309*(2), 1–10.

Zulfa, R., Lestari, I. R., Zahraini, W., & Syukur, A. (2024). Materi zat adiktif paa budaya sasak Mako Gecok untuk pengembangan bahan pembelajaran IPA. *Jurnal Ilmiah Profesi Kependidikan*, *9*(2), 1501–1508. https://doi.org/10.29303/jipp.v9i2.1165