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Development of Spinning Wheel-Based Question Thread Pull Media on Atomic Structure Material to Train Student Communication Skills

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Abstract: Atomic structure material is important to learn and understand because it is the basis of chemistry learning, but in reality, it is still found that students' academic abilities are lacking in this material. In addition, students' communication skills are still relatively poor in the learning process. Therefore, innovative learning media is needed that can improve students' academic ability in atomic structure material and communication skills at the same time. Media are materials and tools used to help the process of delivering information. One of the media that can be an alternative to overcome existing chemical problems is the spinning wheel-based question thread pull media, which is a media in the form of practice questions, and the answers must be communicated directly. The purpose of this study was to determine the validity of spinning wheel-based question thread pull media as a learning media to train communication skills on atomic structure material. This type of research is Research and Development (R&D) with the 4D (four-D) model, namely define, design, develop, and disseminate. However, this research is limited to the development stage only, which focuses on media validation. The research instrument used was a validation sheet given to three validators, namely two lecturers from the Chemistry Education Study Program and one chemistry teacher. The data analysis technique used is the mode. The results showed that the content validity and construct validity of the spinning wheel-based question thread pull media in each aspect of the assessment were ≥ 3, with a good category. So it can be concluded that the spinning wheel-based question thread pull media developed is declared valid as a learning media in schools to train the communication skills of class X senior high schools or Islamic high school students on atomic structure material. For further research, it is recommended that the media carry out a limited trial as well, so that its practicality and effectiveness can be known.

Keywords: Atomic Structure; Communication Skills; Question Thread Pull Media; Spinning Wheel; Validation.

Introduction

At the senior high school education level, students are taught various fields of science, one of which is chemistry [1]. Chemistry is a branch of science that studies the structure, properties, and changes in matter [2], [3], [4]. One of the materials in the Chemistry subject is atomic structure. Atomic structure is material taught in class X that requires reasoning in the form of concepts that require understanding, memorization, and calculation. The concepts in chemistry are generally complex, so that they require scientific reasoning and learning chemistry is a mental activity that requires high reasoning [5], [6].

Atomic structure material is important to learn and understand because it is the basis of learning Chemistry, to understand Chemistry as a whole [7]. However, many students have difficulty understanding the atomic structure material. Based on one of the results of the research, it is concluded that students have difficulty in solving problems on the subject of atomic structure. The test results of conceptual questions show that there are still many students who are wrong in answering questions, amounting to 59.73% in the moderate category. Meanwhile, the test results of calculation-shaped questions, there are still many students who are wrong by 74.91% in the high category [8]. This is also supported by the results of interviews with chemistry teachers at one of the senior high schools in Surabaya, where the learning outcomes of students on atomic structure material show that as many as 66.7% of students are above the KKM, while 33.3% are still below the KKM. Chemistry is one of the fields of science that is not favored by students because it is considered a difficult and boring subject by most students [9], [1]. This can be caused by one of the factors, such as the teacher's learning model or the media that is not appropriate for teaching. Conventional methods, such as lectures that are more often used by teachers, are not suitable for many Chemistry materials [10], [11].

One of the must-have skills in 21st-century learning is communication skills. The must-have skills of the 21st century are formulated in the media that are not appropriate for 4C, namely: Critical thinking, Creativity, Collaboration, and Communication [12], [13]. Communication skills by verbal means (oral) consist of questioning skills and opinion skills. Questioning skills are utterances or statements that are thrown, which demand a response or answer [14], [15]. Meanwhile, opinion skills are the ability to convey ideas or thoughts orally in a logical manner using good language [16]. Communication skills are the most important element to determine the success of a lesson, where there is a transfer of knowledge from the communicator, namely the educator and students as communicants [17], [18].

During the learning process, learners are not easily able to convey their ideas or ideas because they do not have adequate communication skills. Learners who do not have

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the courage to convey ideas will cause them to be passive, feel shy, not confident, and insecure [19]. This is supported by the results of a pre-research questionnaire that has been conducted on class X students of one of the senior high schools in Surabaya, showing that the quantity of students' questioning skills is 48.4% and the quantity of opinion skills is 74.2% percentage, which is in the "rarely" category. In addition, the quality of students' questioning and opinion skills is also still in the low category, which is done by giving a news description, and then students are asked to ask a question. In fact, students have been trained in communication skills by chemistry teachers.

Based on the description of Chemistry learning problems above, teachers must be creative in juxtaposing learning models and media [20]. Learning models combined with good and suitable media will make learning effective, fun, and motivate students to be active. Learning media is a learning component that includes materials and equipment [21], [22]. The learning process will be helped by the media as a means of learning information. Learning will be more interesting, fun, and easy to understand with the help of media in the teaching and learning process [23]. This is in line with the results of the pre-research questionnaire that has been conducted that as many as 96.8% of students feel learning with the help of learning media is easier and more fun.

One of the learning media that can be used to improve students' understanding of atomic structure material and practice communication skills at the same time is the spinning wheel-based question thread pull media. A spinning wheel is a circular game divided into several color parts that are played by rotating according to its axis and stopping at one of the colors in the circle [24]. Spinning wheel has the advantage of being able to provide stimulus to learners to actively participate and provide direct reciprocal responses for effective learning [25], [26]. Meanwhile, question thread pull media is a media developed from the traditional game of pulling the thread. This game is played by pulling a thread that contains a prize [27].

The question thread pulls media that researchers want to develop, containing problem cards and question cards. Problem cards have different colors that indicate cognitive level C1-C6. Meanwhile, question cards contain Figures that require learners to ask a relevant question. The question thread pulls media, which is played offline in conjunction with the spinning wheel, which is played online. The spinning wheel is used to determine the color of the card that learners must take on the question thread pull media.

Based on the background description above, the researcher is interested in conducting research with the title "Development of Spinning Wheel-Based Question Thread Pull Media on Atomic Structure Material to Train Learners' Communication Skills" with the aim of knowing the validity of spinning wheel-based question thread pull media as learning media in schools to train communication skills of class X senior high schools or islamic high school students on atomic structure material.

Research Methods

The type of research used in this study is Research and Development (R&D). Research and Development is a process or stage to obtain a new result or improvement of existing results, which can be accounted for and tested for the effectiveness of these results [28]. Meanwhile, the research model uses Thiagarajan's 4D (four-D) model, which consists of 4 stages, namely define, design, develop, and disseminate [29], [30]. However, this study was limited to the development stage only, which focused on media validation by three experts (validators). This research was conducted for six months in the even semester of the 2024/2025 academic year at Surabaya State University and one of the senior high schools in Surabaya. The subjects in this study involved three validators, namely two lecturers from the Chemistry Education Study Program and one chemistry teacher. The validation process was conducted face-to-face or approximately one month.

The instrument used is a media validation sheet containing a set of written statements that must be assessed by the validator, in terms of content validity (five aspects) and construct validity (six aspects). The data analysis technique uses the mode. The mode is the value that appears most often in a data set. The mode is more often applied to categorical or qualitative data [31]. The assessment of the validation results refers to the Likert scale value with a very unfavorable rating scale, mode score 1 to very good, mode score 4, which is presented in Table 1.

Table 1. Likert Scale Rating

Criteria	Scale
Not very good	1
Not good	2
Good	3
Very good	4

[32]

Spinning wheel-based question thread pull media is said to be valid if it obtains a mode value ≥ 3 with a good category from the results of validation by three validators.

Results and Discussion

The product produced from this development research is a spinning wheel-based question thread pull media as a learning media on atomic structure material. The purpose of this study was to determine the validity of the spinning wheel-based question thread pull media as a learning media in schools to train the communication skills of class X SMA / MA students on atomic structure material. The results of the research and discussion will be described based on Thiagarajan's 4D development procedure, but only 3 stages are carried out, namely define, design, and develop.

Define Stage

The define stage aims to determine and formulate the needs in the learning process [33]. Thiagarajan analyzed five activities at the define stage, namely: front-end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives [34]. This stage was carried out using instruments in the form of questionnaires to students and interviews with chemistry teachers. In the first activity, an initial analysis was carried out to identify and determine the basis of the problems faced in the learning process so that the background of the need for development, namely curriculum analysis, difficulty understanding atomic

structure material, 21st century demands to master 4C skills, one of which is communication skills.

The second activity, learner analysis, aims to identify the characteristics of students who are the target of media development, so that the media can be tailored to the needs and characteristics of students [35]. The analysis of students is based on students of class XE-3 one of the senior high schools in Surabaya which is the target of research, starting from cognitive development which is in the age range of 16 to 17 years so that according to Piaget's cognitive development theory, on average, it enters the formal operational stage [36]. Then, the academic ability of students is still in the medium category because as many as 33.3% are still below the KKM. The communication skills of asking students amounted to 48.4% and the quantity of opinion skills amounted to a percentage of 74.2%, which was in the "rarely" category. In addition, the quality of students' questioning and opinion skills is also still in the low category. Finally, according to the results of interviews with chemistry teachers, most students have a visual learning style of 70%.

In the third activity, task analysis is carried out to determine the tasks that must be done by learners and identify the skills studied by researchers [29]. The task of learners is to carry out several activities according to the teacher's direction and must master the communication skills of asking questions and expressing opinions. Fourth, concept analysis is carried out by identifying the main concepts of atomic structure material that will be taught to students in accordance with learning outcomes and detailing the concepts [29]. Fifth, the formulation of learning objectives that refer to the learning outcomes listed in the independent curriculum regarding the atomic structure material [37].

Design Stage

In the design stage, researchers have made initial products (prototypes) or product designs [38]. Thiagarajan divides the design stage into four activities, namely: constructing a criterion-referenced test, media selection, format selection, and initial design [39]. The first activity, the preparation of standard tests for the learning outcomes of the cognitive domain, is adjusted to learning objectives using pretests and posttests. Second, media selection aims to determine the learning media that best suit the characteristics of the material and the needs of students, so that the learning objectives that have been designed can be achieved optimally. The media that researchers choose to develop is a question thread pull media combined with a spinning wheel on atomic structure material in the form of varied question exercises using question cards and question cards that must be communicated directly. Thus, this media is in accordance with the results of the defining stage analysis.

The third activity, format selection, aims to formulate the design of learning media, selection of strategies, approaches/models, methods, and learning resources [29]. The media developed in this study were designed by combining online and offline media. Online media uses the help of a website. Meanwhile, offline media is printed using cardboard art paper and packaged in media boxes. Fourth, the initial product (prototype) or product design is made. The preparation and design of spinning wheel-based question thread pull media includes making spinning wheels, question thread pulls in the form of a collection of problem cards and question cards, as well as a guidebook for using the media.

The spinning wheel is adapted from the website spinthewheel.io. Users can access the spinning wheel through the link https://spinthewheel.io/wheels/ju0G1oEZNL2H3KwC49dXcz0xJmU9MA%3D%3D online, so you need to make sure you're connected to the internet. This spinning wheel is accompanied by audio. The spinning wheel display can be seen in Figure 1.

Figure 1. Spinning Wheel Display

The question thread pulls media is played directly, which contains problem cards and question cards. These problem cards and question cards have been converted into the form of barcodes. Problem cards and question cards are printed using art cardboard paper so that they are thick and not easily damaged, with a size of 9 cm long and 7 cm wide. Then, the top of the card was cut to tie the thread. All problem cards and question cards were tied together using colorful yarn. The question thread pull media is packaged in a media box measuring 15 x 15 cm. This media was developed in two sets, namely the first meeting and the second meeting. Each set consists of 48 problem cards (each cognitive level 8 problem cards), 15 question cards, a media box, wire and plasticine, and a guidebook. The appearance of the media box and the question thread pull media and media box can be seen in Figures 2 and 3.

Figure 2. Question Thread Pull Media Books Display

Problem cards are cards that contain questions that must be answered by students. Problem cards have different colors that indicate the cognitive level. Where cognitive level C1 is blue, C2 is green, C3 is yellow, C4 is orange, C5 is pink, and C6 is red. Meanwhile, the purple question card contains an image related to atomic structure material and then students are asked to ask a question. Question cards and question cards have two sides, namely the front and the back. On the front, there is a barcode that contains an image when scanned, while the back has a question thread and an image of Rutherford's atomic structure. The appearance of the front and back of the question card and question card can be seen

in Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, and Figure 10.

Figure 3. Question Thread Pull Media Display

Figure 4. C1 Problem Card Display

Figure 5. C2 Problem Card Display

Figure 6. C3 Problem Card Display

Figure 7. C4 Problem Card Display

Figure 8. C5 Problem Card Display

Figure 9. C6 Problem Card Display

Figure 10. Question Card Display

Spinning wheel-based question thread pull media is equipped with a guidebook that serves as a guide for teachers and students while using the media, which is printed in A5 size and bound. This guidebook provides an overview of the media, learning objectives, learning activities, equipment,

media display, how to use the spinning wheel, and game rules. The teacher's guidebook is equipped with an answer key for question cards and question cards while the learner's guidebook is not. The contents of the guidebook include cover, introduction, content, and cover. The appearance of the teacher's and learner's guidebooks can be seen in Figure 11.

Figure 11. Guidebooks Display

Develop Stage

The develop stage aims to produce learning devices that have been revised based on input from experts [34]. Thiagarajan divides the development stage into two activities, namely expert appraisal dan developmental testing [40]. In this study, the development stage was only up to expert appraisal. The validation process was carried out with three experts (validators) to assess the validity of the product design that had been prepared and get criticism and suggestions. Product validation uses a validation instrument sheet that is prepared in accordance with content validity and construct validity.

Validity is the extent to which the test measures what it is intended to measure. Validity of research instruments can be done based on content and construct [41]. A research instrument that has been declared valid means that the instrument can measure the variables to be measured [32]. The results of the validation recap by three validators of the spinning wheel-based question thread pull media are described as follows.

Table 2. Content Validity Results

No	Assessment Aspect	Mode	Criteria
1.	Correctness of knowledge concepts	4	Very good
2.	Suitability of material with Learning Outcomes (CP) and Learning Objectives (TP)	4	Very good
3.	Suitability of the material to the level of thinking	4	Very good
4.	Suitability of material with learning outcomes	4	Very good
5.	Suitability of material with questions in the media	4	Very good

Based on Table 2, it can be seen that all indicators in the content validity of the spinning wheel-based question thread pull media obtained a mode score of 4 with very good criteria. Thus, the spinning wheel-based based question thread pull media media is said to be feasible in terms of content validity. Content validity shows how the items in the validation instrument are in accordance with the components to be measured [42].

In the first aspect, it indicates that the chemical concepts in the spinning wheel-based question thread pull media are relevant and there are no misconceptions. Effective learning media must be able to convey information in a clear and structured manner and facilitate deep understanding [43]. In the second aspect, indicating that the material used in the spinning wheel-based question thread pull media, namely, atomic structure material, is in accordance with the learning outcomes and learning objectives. Based on the learning outcomes of the independent curriculum, atomic structure material is in phase E [37]. Then, the learning outcomes are derived into learning objectives. The media developed must be in accordance with the objectives to be achieved in the learning process [43]. In making learning objectives, there are several components that must be met, including Audience, Behavior, Condition, Degree or commonly abbreviated as ABCD [44].

In the third aspect, indicating that the material is in accordance with the thinking skills of students, namely High Order Thinking Skills (HOTS) and Lower Order Thinking Skills (LOTS) [45]. Lower Order Thinking Skills (LOTS) if the questions are at the revised Bloom taxonomy levels C1 (remember), C2 (understand), and C3 (apply), while High Order Thinking Skills (HOTS) if they are at the revised Bloom taxonomy levels C4 (analyze), C5 (evaluate), and C6 (create) [46]. The problem cards and question cards in the spinning wheel-based question thread pull media are adjusted to the level of Bloom's revised taxonomy cognitive level, ranging from C1-C6, so that they are in accordance with the level of thinking of both LOTS and HOTS students. In addition, because it uses the level of cognitive levels, the types of questions in the question cards and question cards have a variety of difficulty levels from basic (remembering) to complex (creating).

In the fourth aspect, it is indicated that spinning wheel-based question thread pull media can increase knowledge about atomic structure material with the learning-by-play method. The learning-by-play method is a learning activity that emphasizes learning activities colored by playing activities, so as to make learning activities more exciting and fun [47]. Based on the daily test data of students in class XE-3, one of the senior high schools in Surabaya, who are the research subjects, as many as 33.5% of students are still below the *KKM* on atomic structure material. Therefore, the problem cards and question cards in this spinning wheel-based question thread pull media cover the entire atomic structure material starting from the theory of atomic development consisting of Dalton, Thomson, Rutherford, Bohr, and quantum mechanics atomic theories; atomic constituent particles (protons, electrons, and neutrons); atomic notation; isotopes; isobars; isotones; and electron configuration [48].

In the fifth aspect, indicating that the items, along with the answer key for the spinning wheel-based question thread pull media, did not deviate from the atomic structure material, both concepts, images, and formulas used. All of the items in the spinning wheel-based question thread pull

media are types of description questions. In writing the form of description questions, there are four aspects of the material that must be considered, including: (1) the question must be in accordance with the indicator, (2) the limits of the question and the expected answer must be clear, (3) the content of the material is in accordance with the measurement instructions, and (4) the content of the material asked is in accordance with the level [49].

Table 3. Construct Validity Results

No	Assessment Aspect	Mode	Criteria
1.	Media is easy to use by teachers and learners	3	Good
2.	Encourages the development of specific skills	4	Very good
3.	Appropriateness to the characteristics of learners	4	Very good
4.	Rules in the media	3	Good
5.	Challenging and actively engages learners	4	Very good
6.	Visual display design of media	4	Very good

Based on **Table 3**, It can be seen that all aspects in construct validity obtained a mode score ≥ 3 good criteria. Thus, the spinning wheel-based question thread pull media is said to be feasible in terms of construct validity. Construct validity is a description that shows the extent to which the measuring instrument shows results that are in accordance with the theory [50].

In the first aspect, it indicates that the spinning wheel-based question thread pull media was easy to use in learning by teachers and students. The benefit of media in the learning process is to facilitate interaction between teachers and students so that learning activities will be more effective and efficient [51]. In the second aspect, the spinning wheel-based question thread pull media is designed to help train oral communication skills, namely, asking and arguing skills. The communication skill of asking is trained through the question card, while the communication skill of arguing is trained through the problem card. Based on the results of pre-research on students of class XE-3, one of the senior high schools in Surabaya. which is the subject of the research, the communication skills of asking questions and arguing are still in the category of rarely used during learning, even though they have been trained by chemistry teachers. In fact, communication skills are one of the 4C skills that are required to be mastered in the 21st century [12].

In the third aspect, indicating that the spinning wheel-based question thread pull media was in accordance with the characteristics of students in class XE-3, one of the senior high schools in Surabaya, who were the research subjects, ranging from learning styles and age of cognitive development. Based on the results of interviews with Chemistry teachers, it is known that around 70% of students have a visual learning style. The spinning wheel-based question thread pull media is designed to be as interesting as possible by combining online and offline media so that it suits the visual learning style of students. Visual learning style is a process of receiving information related to the sense of sight (eyes) [52]. In addition, students are generally in the age range of 16 to 17 years so that according to Piaget's cognitive development theory, on average, they enter the formal operational stage [36]. At this stage, individuals begin to be able to think abstractly, logically, and systematically. Learners are expected to have the ability to think rationally, solve problems, and understand the relationship between existing materials [53]. However, grade X students are still in the age range of 7-18 years who still have an interest in activities that involve elements of play [54]. Thus, the spinning wheel-based question thread pull media is suitable for the age of students.

In the fourth aspect, indicating that the rules in the spinning wheel-based question thread pull media are easy to understand. The spinning wheel-based question thread pull media is equipped with a guidebook that contains a media overview, media display, equipment, and game rules to make it easier for students to understand the media so they can win the game. The development of game media must be equipped with a guidebook to make it easier for students and teachers in learning activities [55].

The fifth aspect indicates that the spinning wheel-based question thread pull media is challenging and actively involves learners. This media contains problem cards and question cards that learners must complete to earn points. The implementation of the media is juxtaposed with the cooperative learning model, which at the end of the syntax gives awards to the group [56]. Learners will want to win by scrambling for the highest points and getting awards, so as to encourage active involvement. Interesting and interactive media allow learners to be more involved in learning, so they feel more motivated to learn [43].

The sixth aspect indicates that the media display is generally able to attract the attention of users, both in terms of colour selection, illustrations, layout, and other visual elements. Learning media must pay attention to the preparation of clear text, the use of colors, fonts, and the right layout [43]. Then, the spinning wheel-based question thread pulls media that combines text, animation, images, and audio elements. Text and image elements are made clear and in accordance with the atomic structure material. This is in line that interesting learning media must have the ability to combine all media elements, such as text, video, animation, image, graphics, and sound [57]. In addition, the spinning wheel-based question thread pull media is designed to be as attractive as possible, with a precise layout and using colors that are not too flashy. The questions in the spinning wheel--based question thread pull media are also converted into barcodes so that the text can be read clearly.

Based on the results of other studies on the validation of a media, Lucky Draw Chemist media based on the website validated by three experts, it was concluded that Lucky Draw Chemist media was declared valid based on content and construct validity. Thus, Lucky Draw Chemist, media media-based on the website developed, is declared feasible to improve students' analytical skills on chemical bonding materials [58]. In addition, the results of other studies show that there is a significant difference in Game Spinning Wheel learning media on the learning activity of students on the material of the coordination system of class XI IPA at SMA Negeri Arjasa Jember [59].

Conclusion

Based on the results of data analysis of the spinning wheel-based question thread pull media validation sheet, three experts were consulted, and it is known that the content validity and construct validity of the spinning wheel-based question thread pull media on each aspect of the assessment are ≥ 3 with good criteria. So it can be concluded that the spinning wheel-based question thread pull media developed is declared "valid" as a learning media in schools to train the communication skills of class X senior high schools or Islamic high school students on atomic structure material. Furthermore, it is recommended that further research be conducted to determine the practicality and effectiveness of this media in training students' communication skills. The implication of the spinning wheel-based thread pulling media developed can be useful as an alternative learning media that makes learning more effective and efficient by encouraging students to actively communicate and become a means of creating meaningful and enjoyable learning experiences. In accordance with the independent curriculum, communication skills are one of the important skills that must be possessed in the 21st century.

Author's Contribution

Adellia Nur Khasanah: Conceptualization, media development, data collection, data analysis, and manuscript writing. Rusmini: Supervision, validation, and review of the manuscript.

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References

[1] A. Priliyanti, I. Muderawan dan S. Maryam, "Analisis Kesulitan Belajar Siswa dalam Mempelajari Kimia Kelas XI," *Jurnal Pendidikan Kimia Undiksha,* vol. 5, no. 1, doi: https://doi.org/10.23887/jjpk.v5i1.32402, pp. 11-18, 2021.

[2] F. Dewi, B. Efrianto dan A. Afrida, "Analisis Keterlaksanaan Pendekatan Experiential Learning dan Pengaruhnya terhadap Keterampilan Proses Sains Siswa pada Materi Ikatan Kimia," *Journal of The Indonesian Society of Integrated Chemistry,* vol. 10, no. 1, doi: https://doi.org/10.22437/jisic.v10i1.5307, pp. 1-8, 2018.

[3] F. O. Myranthika, Modul Pembelajaran SMA KIMIA, Jakarta: Kemendikbud Ditjen PAUD Dikdasmen, 2020.

[4] N. P. J. Artini dan I. K. W. B. Wijaya, "Strategi Pengembangan Literasi Kimia Bagi Siswa SMP," *Jurnal Ilmiah Pendidikan Citra Bakti,* vol. 7, no. 2, doi: https://doi.org/10.38048/jipcb.v7i2.97, pp. 100-108, 2020.

[5] A. Purwandani, A. Lutfi dan R. Hidayah, "The Development of Chem Man Computer Game as Atomic Constituent Particles Learning Media For 10th Grade High School," *Unesa Journal of Chemical Education,* vol. 8, no. 3, 2019.

[6] N. K. Sariati, I. N. Suardana dan N. M. Wiratini, "Analisis Kesulitan Belajar Kimia Siswa Kelas XI pada Materi Larutan Penyangga," *Jurnal Ilmiah Pendidikan Dan Pembelajaran,* vol. 4, no. 1, 2020.

[7] W. U. Wijaya, "Analisis Kebutuhan untuk Mengembangkan Media Video Animasi pada Materi Struktur Atom dan Ikatan Kimia," *JTC-RE: Journal of Tropical Chemistry Research and Education,* vol. 2, no. 1, doi: https://doi.org/10.14421/jtcre.2020.22-02, pp. 59-67, 2020.

[8] N. Afrianis dan L. Ningsih, "Analisis Kesulitan Belajar Siswa Pada Materi Struktur Atom," *Jurnal Pendidikan Kimia dan Terapan,* vol. 6, no. 2, doi: https://doi.org/10.24014/konfigurasi.v6i2.18617, pp. 102-108, 2022.

[9] W. Muderawan, I. G. L. Wiratma dan M. Z. Nabila, "Analisis Faktor-Faktor Penyebab Kesulitan Belajar Kelarutan," *Jurnal Pendidikan Kimia Indonesia,* vol. 3, no. 1, doi: https://doi.org/10.23887/jpk.v3i1.20944, p. 17–23, 2019.

[10] I. P. Subandi, Sudzuasmais, A. D. Triana dan R. Hidayah, "Pengembangan e-LKPD Berbasis Problem Based Learning untuk Meningkatkan Hasil Belajar Peserta Didik pada Materi Minyak Bumi di Era Merdeka Belajar," *UNESA Journal of Chemical Education,* vol. 17, no. 1, doi: https://doi.org/10.26740/ujced.v12n1.p59-66, pp. 59-66, 2023.

[11] E. Sipahutar, "Efektivitas Pembelajaran PAI Menggunakan Strategi Two Stay Two Stray," *Jurnal IMAMAH,* vol. 1, no. 2, pp. 170-174, 2023.

[12] N. Gabriella dan Mitarlis, "Penngembangan LKPD Berorientasi Problem Based Learning (PBL) untuk Meningkatkan Keterampilan Berfikir Kritis pada Materi Hidrokarbon," *UNESA Journal of Chemical Education,* vol. 10, no. 2, p. 103–112, 2021.

[13] I. Nurhayati, K. S. E. Pramono dan A. Farida, "Keterampilan4C (Critical Thinking, Creativity, Communication and Collaboration)dalam Pembelajaran IPS untuk Menjawab Tantangan Abad 21," *Jurnal Basicedu,* vol. 8, no. 1, doi: https://doi.org/10.31004/basicedu.v8i1.6842, pp. 44-53, 2024.

[14] A. Mufarokah, Strategi Belajar Mengajar, Yogyakarta: Teras, 2009.

[15] Hasibuan, Proses Belajar Mengajar, Bandung: PT. Remaja Rosdakarya, 2006.

[16] M. Novita, Penerapan Strategi Pembelajaran Student Facilitator and Explaining untuk Meningkatkan Keterampilan Mengemukakan Pendapat pada Tema Kayanya Negeriku di Kelas IV SDN 005 Bagan Cempedak, Skripsi. Pekan Baru:

Universitas Islam Negeri Sultan Syarif Kasim RIau, 2021.

[17] D. Rosyada, Paradigma Pendidikan Demokratis, Jakarta: Prenada Media, 2004.

[18] H. S. Nilam dan E. Yenti, "Analisis Keterampilan Komunikasi Siswa pada Materi Ikatan Kimia," *Journal of Natural Science Learning,* vol. 2, no. 2, pp. 17-22, 2023.

[19] B. Astuti dan A. I. Pramata, "Hubungan Antara Efikasi Diri dengan Keterampilan Komunikasi Siswa," *Jurnal Penelitian Ilmu Pendidikan,* vol. 13, no. 2, doi: https://doi.org/10.21831/jpipfip.v13i2.33757, pp. 147-155, 2020.

[20] Q. Zuliatin, F. Fatayah dan I. F. Yuliana, "Pengembangan e-LKPD Berbasis STEM (Science, Technology, Engineering, and Mathematic) pada Materi Struktur Atom," *UNESA Journal of Chemical Education,* vol. 11, no. 3, doi: https://doi.org/10.26740/ujced.v11n3.p195-201, p. 195–202, 2022.

[21] W. Kurniawati dan M. Achmad, "Analisis Pembuatan Media Pembelajaran dalam Mata Kuliah Pendidikan Multimedia oleh Mahasiswa Program Studi Teknologi Pendidikan IKIP Mataram," *Jurnal Kependidikan,* vol. 4, no. 2, doi: https://doi.org/10.33394/jk.v4i2.1133, pp. 215-219, 2018.

[22] H. Pagarra, A. Syawaluddin, W. Krismanto dan Sayidiman, Media Pembelajaran, Makassar: Badan Penerbit UNM, 2022.

[23] D. Andriani dan S. Hadijah, "Pengembangan Media Pembelajaran Kuliner Etnis Sulawesi Selatan bagi Mahasiswa Program Studi Vokasi Perhotelan," *Jurnal Kependidikan : Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran,* vol. 7, no. 1, doi: https://doi.org/10.33394/jk.v7i1.3160, pp. 86-96, 2021.

[24] E. F. Harahap, L. M. P. Angin, Nurmayani, R. Sitohong dan E. Mailani, "Pengembangan Media Pembelajaran Spinning Wheel of Question pada Tema 7 Subtema 2 Kelas V di MIN 1 Medan T.A. 2022/2023," *Journal on Education,* vol. 6, no. 2, pp. 12235-12247, 2024.

[25] A. Anggraini, Pengembangan Media Spinning Wheel Pada Pembelajaran Tematik Kelas III di Sekolah Dasar Negeri Pondok Joyo 01 Jember, Skripsi. Jember: Universitas Islam Negeri Kiai Haji Achmad Siddiq, 2023.

[26] E. W. Hariyati, "Pengembangan Media Pembelajaran Spinning Question pada Kompetensi Dasar Kerja Sama Ekonomi Internasional Kelas XI IPS di SMA Negeri 1 Porong," *JUPE,* vol. 6, no. 3, pp. 310-315, 2018.

[27] M. Afhan, "Mengenang Tarik Benang dan Lotre Cabut, Mainan 'Judi' ala Bocah Generasi Awal 2000-an," 2021. [Online]. Available: http://surl.li/liwca. [Diakses 21 September 2023].

[28] N. S. Sukmadinata, Metode Penelitian Pendidikan, Bandung: PT Remaja Rosda-Karya, 2009.

[29] S. Thiagarajan, D. Semmel dan M. Semmel, Instructional Development for Training Teachers of Exceptional Children, Indiana: Indiana University Bloomington, 1974.

[30] Nelda, B. Holiwarni dan L. Anwar, "Development of Student Worksheet Based on MEA Model of Ionic Equilibrium and PH of Buffer Solution for Senior High School," *Jurnal Pijar MIPA,* vol. 17, no. 1, doi: https://doi.org/10.29303/jpm.v17i1.2383, pp. 118-122, 2022.

[31] M. Faisal Eka, I. Rusani, A. Maryam, R. Andini dan N. Yuliani, "Analisis Kemampuan Penyelesaian Soal Modus Median Dan Mean Mahasiswa Pendidikan Matematika Pada Mata Kuliah Statistik Di Universitas Muhammadiyah Sorong," *Jurnal Qalam,* vol. 13, no. 2, pp. 47-54, 2024.

[32] Sugiyono, Metode Penelitian Pendidikan: Pendekatan Kuantitatif, Kualitataif, dan R&D, Bandung: Alfabeta, 2015.

[33] D. P. Pranata, A. Frima dan A. S. Egok, "Pengembangan LKS Matematika Berbasis Problem Based Learning pada Materi Bangun Datar Sekolah Dasar," *Jurnal Basicedu,* vol. 5, no. 4, doi: https://doi.org/10.31004/basicedu.v5i4.1183, pp. 2284-2301, 2021.

[34] R. Ade, A. Z. Nasichah dan A. Mas'ud, "Development of Comics Media to Improve Science Literacy and Concepts Understanding Junior High School Students in Central Halmahera Regency Through Reading Literacy Program," *Jurnal Pijar MIPA,* vol. 20, no. 1, doi: https://doi.org/10.29303/jpm.v20i1.8327, pp. 1-6, 2025.

[35] D. W. Wahyuningtyas, Pengembangan Media Ular Tangga Cobaku (Coba Tebak Aku) pada Pembelajaran Tematik untuk Meningkatkan Minat Belajar Siswa SD. Skripsi., Pacitan: STKIP Pacitan, 2021.

[36] I. F. Septiyanti, S. Wibawa, Y. Yulia dan B. H. Cahyani, "Kemampuan Berpikir Kritis pada Tahapan Operasional Konkrit," *Wacana Akademika: Majalah Ilmiah Kependidikan,* vol. 7, no. 2, pp. 195-203, 2023.

[37] BSKAP, Capaian Pembelajaran pada Pendidikan Anak Usia Dini, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah pada Kurikulum Merdeka, Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2024.

[38] A. P. Arum, "Strategi Pembelajaran Kooperatif Pada Mata Kuliah Penataan Rambut," *Jurnal Teknologi Pendidikan,* vol. 22, no. 2, doi: https://doi.org/10.21009/jtp.v22i2.16490, pp. 132-139, 2020.

[39] M. A. Kurniawan, "Pengembangan Media Diorama Proses Pembentukan Stalakmite Stalaktite pada Mata Kuliah Geomorfologi Jurusan Pendidikan

Geografi Universitas Negeri Surabaya," *Jurnal Pendidikan Geografi* , pp. 1-8, 2022.

[40] U.-U. TIM PDK, Modul Ajar Penelitian dan Pengembangan Atau Research and Development (R&D), Ternate: Universitas Khairun, 2023.

[41] W. D. Puspitasari dan F. Febrinita, "Pengujian Validasi Isi (Content Validity) Angket Persepsi Mahasiswa Terhadap Pembelajaran Daring Matakuliah Matematika Komputasi," *Focus Action Of Research Mathematic,* vol. 4, no. 1, doi: https://doi.org/10.30762/factor_m.v4i1.3254, pp. 77-90, 2021.

[42] A. N. Widowati dan B. Yonata, "Validitas Worksheet Diperkaya dengan Wordwall Quiz untuk Melatihkan Keterampilan Berfikir Kritis pada Materi Konfigurasi Elektron," *UNESA Journal of Chemical Education,* vol. 12, no. 3, doi: https://doi.org/10.26740/ujced.v12n3.p179-188, pp. 179-188, 2023.

[43] E. Rochaendi, A. Fuadi dan D. A. Sholihah, Pengembangan Media Pembelajaran, Sumatra: Institut Teknologi Sumatera (ITERA) PRESS, 2024.

[44] M. A. R. Pitasari dan B. D. Febriyanti, "Analisis Kelengkapan dalam Merumuskan Tujuan Pembelajaran pada Mahasiswa PGMI Semester V," *Qalam: Jurnal Ilmu Kependidikan,* vol. 12, no. 1, doi: https://doi.org/10.33506/jq.v12i1.2554, pp. 35-42, 2023.

[45] I. N. Azizah dan I. Silfianah, "Pengembangan Instrumen Penilaian Kognitif Berbasis Higher Order Thingking Skills (HOTS) Berbantu Aplikasi Quizizz pada Materi Ikatan Kimia dan Gaya Antarmolekul," *UNESA Journal of Chemical Education,* vol. 13, no. 2, doi: https://doi.org/10.26740/ujced.v13n2.p159-170, pp. 159-170, 2024.

[46] E. Nurjanah, G. M. Ramadhan dan L. Diana, "Analisis Soal Tipe High Order Thingking Skill (HOTS) pada Soal Penilaian Akhir Semester (PAS) Tematik Ganjil Kelas V SDN Selakaso Tahun Ajaran 2020/2021," *Journal of Elementary Education,* vol. 5, no. 2, doi: https://doi.org/10.22460/collase.v5i2.10590, pp. 308-315, 2020.

[47] M. Ilma dan R. A. Nurhidayati, "Program Belajar Sambil Bermain dalam Upaya Peningkatan Minat dan Semangat SIswa di Masa Pandemi Covid-19," *Jurnal Pengabdian Kepada Masyarakat,* vol. 2, no. 1, doi: https://doi.org/10.35329/sipissangngi.v2i1.2512, pp. 45-53, 2022.

[48] A. Nurfitriana, E. Enawaty, A. I. Harun, R. Sahputra dan M. Ulfah, "Pengembangan Media Video Animasi pada Materi Perkembangan Model Atom," *Edukatif : Jurnal Ilmu Pendidikan,* vol. 4, no. 2, doi: https://doi.org/10.31004/edukatif.v4i2.2032, pp. 2435-2436, 2022.

[49] S. Anggraeni, V. Pandra dan L. A. Purwasi, "Analisis Soal Cerita Matematika pada Materi Bangun Datar Kelas IV Sekolah Dasar," *Journal of Elemantary School (JOES),* vol. 6, no. 2, doi: https://doi.org/10.31539/joes.v6i2.6739, pp. 272-279, 2023.

[50] S. Azwar, Dasar-Dasar Psikometri, Yogyakarta: Pustaka Pelajar, 2005.

[51] A. P. Wulandari, A. A. Salsabila, K. Cahyani, T. S. Nurazizah dan Z. Ulfiah, "Pentingnya Media Pembelajaran dalam Proses Belajar Mengajar," *Journal on Education,* vol. 5, no. 2, doi: https://doi.org/10.31004/joe.v5i2.1074, pp. 3928-3936, 2023.

[52] L. Rahmawati dan S. Gumiandari, "Identifikasi Gaya Belajar (Visual, Auditorial, dan Kinestetik) Mahasiswa Tadris Bahasa Inggris Kelas 3F IAIN Syekh Nurjati," *Pedagogik Jurnal Pendidikan,* vol. 16, no. 1, doi: https://doi.org/10.33084/pedagogik.v16i1.1876, pp. 55-56, 2021.

[53] M. Janah, Pengembangan Media Pembelajaran Kimia Berbasis Joyful Learning dengan Permainan Ular Tangga pada Materi Stoikiometri untuk Meningkatkan Hasil Belajar Peserta Didik, Surabaya: Universitas Negeri Surabaya, 2023.

[54] R. Aulya, Zulyusri dan Rahmawati, "Media Pembelajaran Berbentuk Kartu dengan Metode Permainan UNO pada Materi Protista," *Jurnal Penelitian dan Pengembangan Pendidikan,* vol. 5, no. 3, doi: https://doi.org/10.23887/jppp.v5i3.34743, pp. 421 - 428, 2021.

[55] H. Wicaksono, Pengembangan Media Permainan Imajinasi dalam Pembelajaran Menulis Puisi, Malang: Universitas Negeri Malang, 2018.

[56] Y. C. Nisyah, F. Dewi dan Syamsuriza, "Korelasi Model Kooperatif STAD Secara Daring Terhadap Kemampuan Berfikir Kritis Siswa pada Materi Larutan Penyangga," *UNESA Journal of Chemical Education,* vol. 11, no. 1, doi: https://doi.org/10.26740/ujced.v11n1.p70-77, pp. 70-77, 2022.

[57] Y. Munadi, Media Pemelajaran, Jakarta: Gaung Persada Press., 2008.

[58] S. I. Sukma, Pengembangan Lucky Draw Chemist Berbasis Web Sebagai Media Pembelajaran Untuk Meningkatkan Kemampuan Analisis Peserta Didik Pada Materi Ikatan Kimia. Skripsi, Surabaya: Universitas Negeri Surabaya, 2024.

[59] N. Fiqriani, Pengaruh Penggunaan Media Pembelajaran Game Spinning Wheel Terhadap Minat dan Keaktifan Belajar Siswa pada Materi Sistem Koordinasi Kelas XI IPA SMA Negeri Arjasa Jember Tahun Pelajaran 2022/2023, Skripsi. Jember: Universitas Islam Jember, 2023.