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Development of Teaching Materials Based on Contextual Teaching Learning (CTL) in Physical Chemistry Courses

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Abstract: This research aims to produce teaching materials for the Physical Chemistry course that are based on the Contextual Teaching and Learning (CTL) approach that is valid, practical and effective. This research is included in the type of development research that adopts the 4D Model, which has been modified by the researcher from four steps to three research steps. The analysis was carried out in two stages, namely problem analysis and needs analysis. The validity of teaching materials involves material experts, media experts and language experts. The practicality of teaching materials is assessed by filling out a questionnaire by users of teaching materials, namely lecturers and students. The product was tested on students of the Chemistry Education Study Program at Muhammadiyah University, Pontianak. Based on the analysis of student needs, it was found that students need learning resources for Physical Chemistry courses that are based on the Contextual Teaching and Learning (CTL) approach which can support skills in relating the material studied to everyday life. The techniques used are observation, interviews, validation questionnaires and student response questionnaires. The results obtained were that the validity of the material aspect was 98.75%, the media was 87.33%, and the language was 98.00%, which fell into very valid criteria. Practicality based on the student response questionnaire score in individual trials was 95.8% and in small group trials was 89.6%, which is very practical criteria. The effectiveness value obtained on average was 0.67 in individual trials which were in the high criteria and 0.82 in small group trials in the very high criteria.

Keywords: CTL; Development of teaching materials; Physical chemistry

Introduction

The achievement of educational goals that have been set is determined by several factors such as teachers, students, learning approaches, textbooks, and other supporting factors (Smith, 2020). If one of these factors is not implemented, learning will not be successful and run smoothly (R. Johnson, 2018). Learning will be more meaningful if students experience what they are learning, not just know it (Kolb, 1984). It is hoped that the concepts of lecture material can be integrated in real life contexts with the hope that students can understand what they learn better and more easily through contextual learning (J. S. Brown et al., 2005).

One of the courses in the chemistry education study program is the physical chemistry course. Physical chemistry is a part of chemistry that studies natural phenomena and symptoms in inanimate objects empirically, logically, systematically and rationally involving scientific processes and attitudes (Atkins et al., 2014). Learning physical chemistry with all the processes in it will be more meaningful if studied contextually by involving students in exploring to form competencies by exploring the potential for scientific truth (Gilbert et al., 2009). Learning Physical Chemistry can grow students' thinking abilities to solve problems in everyday life (Huang et al., 2007).

Student success in learning physical chemistry really depends on the way the lecturer teaches. In

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planning learning, what lecturers need to prepare are teaching materials according to the topic of discussion (Vavoula et al., 2009). Teaching materials are selected taking into account the level of development and abilities of students, arranged in detail and systematically (Biggs et al., 2011). In carrying out teaching, lecturers deliver teaching materials according to the systematics prepared (S. Brown, 2018).

Based on observations made by lecturers while teaching physical chemistry courses, it shows that lecturers have used teaching materials but have not used contextual learning that links the material they teach with students' real world situations and encourages students to make connections between the knowledge they have and its application in their lives as a family and community members. This causes low understanding of concepts which can have an impact on student learning outcomes.

To help students overcome various obstacles in learning, the development of Contextual Teaching and Learning (CTL) based teaching materials is very necessary. This teaching material is designed to support students in achieving learning goals independently (Sutrisno, 2008). The components in this teaching material include general and specific learning objectives, instructions for use, descriptions of the material arranged systematically, pictures or illustrations to clarify the material, summaries, evaluations, reading lists, and answer keys (Dick et al., 1996; E. B. Johnson, 2002).

Contextual Teaching and Learning is a learning approach that places teaching in a real-world context to make it more meaningful for students. This allows lecturers to relate the material taught to situations that are relevant and can be identified by students in everyday life (Hasibuan, 2015). One of the key aspects of contextual learning is encouraging students to link the knowledge they gain with its application in real life contexts (Satriani et al., 2012).

There are seven main components that form an effective learning framework in the context of contextual learning. First, constructivism refers to the concept that students actively construct their own knowledge through interactions with subject matter and the learning environment (Hertz-Lazarowitz, 2008). Second, the questioning aspect is a process where students are encouraged to ask questions, which helps them understand the concepts being taught better (Graesser et al., 2018). Furthermore, discovering refers to students' ability to explore and discover new knowledge through direct experience and experimentation (Hmelo-Silver et al., 2007).

The fourth component, learning community, emphasizes the importance of collaboration and social interaction between students in the learning process (Vygotsky, 1978). Modeling, as the fifth component, involves the use of concrete examples or simulations to illustrate the concepts being taught in a context that is easier for students to understand (Lotze, 2014). The sixth component, reflection, provides opportunities for students to examine and understand their own learning process and its impact on their understanding (Schön, 1987). Finally, authentic assessment involves the use of relevant and contextual assessments to evaluate the understanding and skills students gain in situations that are similar to real life (Wiggins et al., 2005).

Various research has been carried out to develop teaching materials based on Contextual Teaching and Learning (CTL) in the fields of science and mathematics education. Recent studies show that the use of CTL-based materials has had a positive impact on student learning outcomes and motivation. For example, Yudianto et al. (2021) reported the development of a CTL-based e-module for undergraduate physics laboratories that was effective in increasing understanding of physics concepts. Meanwhile, Adlim et al. (2021) and Adlim et al. (2021) developed CTL-based multimedia for a numerical analysis course which succeeded in improving students' problem solving skills.

Other research conducted by Arifin et al. (2020) and Arifin et al. (2020) highlights the effectiveness of CTL-based teaching materials in accounting information systems courses, which help students connect accounting concepts with real-world situations in the business world. On the other hand, Rohmat et al. (2020) developed CTL-based mathematics learning materials which aim to improve students' mathematical communication skills in explaining mathematical concepts clearly and structured. These studies show that the development of CTL-based teaching materials can be an effective strategy in improving students' conceptual understanding and skills in various science and mathematics courses.

The development of teaching materials based on Contextual Teaching and Learning (CTL) has become the focus of research in various fields of education. Widodo et al. (2019) stated that developed CTL-based physics learning materials for high school, which aims to increase students' understanding of physics concepts through relevant contexts in everyday life. Meanwhile, Rachman et al. (2019) and Rachman et al. (2019) developed CTL-based teaching media in a mathematical statistics course, which helps students relate statistical concepts to real-world situations.

Another research conducted by Haris et al. (2018) highlighted the development of CTL-based teaching materials for strategic management courses, which assist students in understanding business management concepts through relevant case studies. On the other hand, Daryanto et al. (2018) developed CTL-based learning materials on ethyl acetate synthesis, which allows students to connect organic chemistry concepts with their application in chemical synthesis.

These studies show that the development of CTL-based teaching materials can be applied in various scientific disciplines. For example, Rahardjo et al. (2017) reported the development of CTL-based biology teaching materials for high schools, which help students understand biological concepts through exploring the natural context around them. In addition, Nugroho et al. (2017) developed CTL-based learning materials about cell division, which allows students to understand complex biological processes through illustrations and relevant case studies.

These studies demonstrate the potential of CTL-based teaching materials in improving student learning outcomes and motivation. However, further research is needed to further explore the effectiveness of these materials across different disciplines and educational levels. This research stands out with several key differences compared to other development research. First, the Contextual Teaching and Learning (CTL) approach is applied specifically to Physical Chemistry courses in higher education, which has rarely been explored before. Most research into the development of teaching materials uses traditional or technology-based approaches, especially at the elementary and secondary levels, not at universities. In addition, this research modifies the 4D Model into three steps, whereas other research generally uses a full development model without modification such as the ADDIE Model or complete 4D Model.

This research also stands out in terms of validation and needs analysis. The validity of teaching materials is evaluated by material, media and language experts, providing comprehensive validation that is often ignored in other research which usually only focuses on one or two aspects. Student needs analysis is carried out in detail to ensure that teaching materials are relevant to their needs and context, in contrast to other research which often conducts general needs analysis. Diverse data collection methods including observation, interviews, validation questionnaires, and student response questionnaires add depth and accuracy to the findings of this research.

In this research, we aim to contribute to the growing literature by developing CTL-based teaching materials in Physical Chemistry courses based on contextual teaching learning to help students apply physical chemistry concepts in everyday life.

Method

The preparation of this learning material adopts the 4D development model designed by Thiagarajan (1974). This development stage consists of four steps, namely define, design, develop and disseminate (Fitriyati, 2015). In this research and development context, the main focus is placed on the development stage, especially small group trials, which involve iteration and adjustments based on feedback obtained from trial participants (Suryadi, 2018).

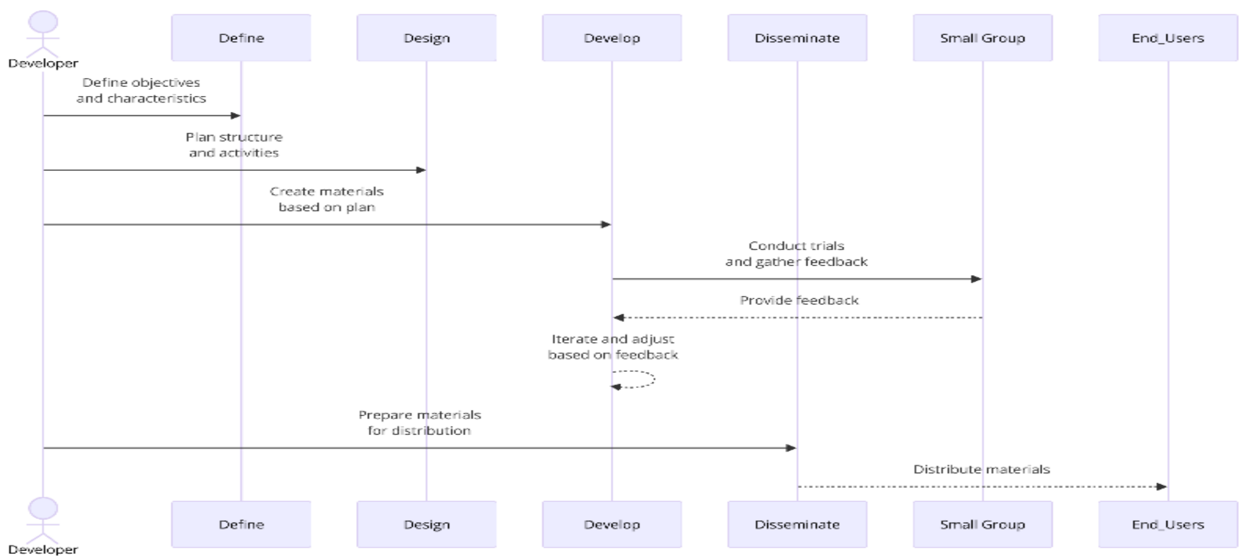

Figure 1. Research method stage

The define stage is the first step in developing learning materials, where the learning objectives and characteristics of students are clearly defined. The design stage involves determining the structure and format of learning materials, as well as planning learning activities that suit the needs of students and the learning objectives that have been set. The development stage is the stage where learning materials are actually created based on a previously designed plan.

During the development stage, testing in small groups is a critical step to evaluate the effectiveness of learning materials before they are distributed widely. In these trials, trial participants provide valuable feedback to improve the quality and suitability of learning materials to their needs. After passing the testing and adjustment stage, the learning materials are ready for dissemination to the target end users, students or training participants (Hadiyoso, 2020). Details regarding the research methods implemented can be found in Figure 1.

The validity of physical chemistry teaching materials is obtained from the results of assessments by material experts and media experts using validation sheets. The validation sheet uses a Likert scale with 4 criteria, namely Strongly Agree (SS), Agree (S), Disagree (TS) and Strongly Disagree (STS (Sugiyono, 2015). The validity criteria according to Fatmawati (2016) are as follows.

Table 1. Validity Criteria

Value Scale (%)	Criteria
0.00 – 50.00	Invalid
50.01 – 70.00	Less valid
70.01 – 85.00	Quite Valid
85.01 – 100.00	Valid

Analysis of the practicality of teaching materials is known based on student questionnaires. Data obtained through questionnaires were analyzed using a Likert scale. The following are the criteria for the practicality of teaching materials (Ja'far et al., 2014).

Table 2. Practicality Criteria

Percentage (%)	Category
0.0 - 20.0	Very Impractical
20.1 – 40.0	Impractical
40.1 – 60.0	Quite Practical
60.1 – 80.0	Practical
80.1 – 100.0	Very Practical

The module is said to be effective if the results of the analysis of improving student learning outcomes provide a significant difference in learning outcomes between before using the physical chemistry module based on Contextual Teaching Learning (CTL) and after using the module. Improvement in student learning outcomes is measured using pretest and posttest results using a One-Group Pretest-Posttest Design then analyzed using the N-Gain formula (Meltzer, 2002) with Equation 1.

$$< g > = \frac{(\text{Spost} - \text{Spre})}{(\text{Maximum score} - \text{Spre})} \quad (1)$$

Description:
Spre = Pretest average score
Spost = Posttest average score
<g> = the size of the gain factor

The criteria for the N-gain formula can be seen in Table 3.

Table 3. Criteria for the N-gain Formula

Value Scale	Category
g ≤ 0.20	Very low
0.21 ≤ 0.40	Low
0.41 ≤ 0.60	Medium
0.61 ≤ 0.80	High
0.81 ≤ 1.00	Very high

Result and Discussion

This research is Research and Development using 3D models to produce products in the form of basic physical chemistry modules that are suitable for use as teaching materials for students. The following displays the physical chemistry module. The results of each stage of the development procedure carried out are as follows.

Define Stage

The define stage is to determine and define the learning requirements. The define stage is divided into 4 parts, namely: Front end analysis, Learner Analysis, Concept analysis, and specifying instructional objectives.

Front end Analysis

At this stage, it is carried out to determine the problems faced in learning, so that the development of teaching materials is needed. Through this analysis, an overview of facts, hopes and alternative solutions to basic problems is obtained which makes it easier to determine or select the teaching materials to be developed. The results of the field study can be concluded that the teaching materials used during teaching, namely PowerPoint (PPT), cannot provide a detailed explanation of the material because they only contain important points without being accompanied by explanations and illustrative examples. This makes it difficult for students to implement it in everyday life. So students expect teaching materials that contain information about material and practical guides as well as examples of physical chemistry material that is contextual to everyday life.

Learner Analysis

The students analyzed in this development research were the students who were the research subjects, namely 12 undergraduate students of the chemistry education study program at Muhammadiyah University of Pontianak, semester III of the 2022/2023 academic year. The results of the analysis showed that students still had difficulty understanding physical chemistry material and finding its relationship in everyday life.

Concept Analysis

Concept analysis in this research is identifying, detailing and compiling the concepts that will be included in the physical chemistry teaching module based on the problems found. The hope is that the module design is made in accordance with the learning objectives in the physical chemistry course. Each section in the module refers to the KKNI curriculum, Student Centered Learning (SCL) learning strategies and the Contextual Teaching Learning (CTL) approach.

Specifying Instructional Objectives

The formulation of learning objectives is adapted to the RPS for the physical chemistry course, namely that students have an understanding of the theory/concepts and physical phenomena in chemical processes. The course discusses units and quantities, gases, thermodynamics I, thermodynamics II, solution equilibrium. Learning will be carried out by applying a student center learning approach, namely through classroom learning, case studies and experiments. Students are encouraged and facilitated to actively seek and discover knowledge and acquire skills and attitudes.

Design Stage

At this stage, a learning device prototype is designed which includes format selection and initial design.

Format Selection

The purpose of choosing a format in developing learning tools is to determine existing learning resource formats and determine the format of learning resources that will be developed. The physical chemistry module is based on Contextual Teaching Learning (CTL). Each part of the module is composed of two or three learning activities. Each learning activity (sub-module section) describes the learning objectives that will be achieved at the meeting, learning materials, exercises, summaries, learning evaluation, feedback and follow-up, as well as a list of references.

Initial Design

The initial design of the physical chemistry module based on Contextual Teaching Learning (CTL) was validated by validators to identify deficiencies and improvements were made before the module was tested. The following is a view of the teaching module cover and inside.

Figure 2. Cover of teaching module and RPS

Develop Stage

The three steps taken at this stage are: validity analysis, practicality analysis, and effectiveness analysis.

Validity Analysis

Material Expert Validation

The results of material validation carried out by 3 validators showed that the physical chemistry module based on Contextual Teaching Learning (CTL) could be used for field trials. The results of the material expert validation recapitulation can be seen in Table 4.

Table 4. Recapitulation of Material Expert Validation

Aspect	Average Percentage	Category
Competence	100.00	Very Valid
Material Quality	97.00	Very Valid
Material Coverage	99.00	Very Valid
Accuracy of Material	99.00	Very Valid
Value in general	98.75	Very Valid

Based on the results from Table 4, the final results of the material expert assessment analysis show a validity percentage of 98.75%. In accordance with the validity criteria, the value is in the very valid criteria (Fatmawati, 2016). So, it can be concluded that the physical chemistry module based on Contextual Teaching Learning (CTL) is suitable for use as a learning resource in terms of material.

Media Expert Validation

This validation was carried out by three validators. The results of the media expert validation recapitulation can be seen in Table 5.

Table 5. Recapitulation of Media Expert Validation

Observed aspects	Average Percentage	Category
Cover Design	90.00	Very Valid
Content Design	86.00	Very Valid
Graphics	86.00	Very Valid
Value in general	87.33	Very Valid

The final results of the media expert assessment analysis in Table 5 show that the media has a validity of 87.33% (very valid). So, it can be concluded that the physical chemistry module based on Contextual Teaching Learning (CTL) is suitable for use as a learning resource from a media perspective.

Linguist Validation

This validation was carried out by three validators. The results of the linguist validation recapitulation results can be seen in Table 6.

Table 6. Recapitulation of Linguist Expert Validation

Observed aspects	Average Percentage	Category
Conformity with Indonesian Language Rules	98.00	Very Valid
Communicative	98.00	Very Valid
Straightforward	98.00	Very Valid
Value in general	98.00	Very Valid

The final results of the linguist assessment analysis in Table 5 show that the media has a validity of 98.00% (very valid). So, it can be concluded that the physical chemistry module based on Contextual Teaching Learning (CTL) is suitable for use as a learning resource from a linguistic perspective.

Practicality Analysis

Individual Trial

Individual trials were carried out on 6 chemistry education students at the Muhammadiyah University of Pontianak semester V who had taken the Physical Chemistry course. Individual trials were carried out to ask for opinions, suggestions and input on the physical chemistry module based on Contextual Teaching Learning (CTL) which was used in small group trials. The results of individual trials show that the practicality percentage level is 95.8% which is in the very practical category. Many students gave positive responses and considered that this module was able to meet their needs in increasing their understanding of physical chemistry concepts. The material presented per chapter is clear and the steps and stages of the process to be achieved are very clear.

Small Group Trials

Small group trials were carried out by providing response questionnaires to see the practicality of the physical chemistry module based on Contextual Teaching Learning (CTL). The response questionnaire was given to 12 students of the chemistry education study program at Muhammadiyah University, Pontianak, semester III who were taking physical chemistry courses. The questionnaire results showed a percentage of 89.6%, falling into the very practical category. Learning outcomes using the physical chemistry module based on Contextual Teaching and Learning (CTL) provide better results, including the benefits of the physical chemistry module based on Contextual Teaching and Learning (CTL) for students in understanding concepts and their application in everyday life are as: helps students to see the relationship between chemical concepts and everyday situations, because physical chemistry material is presented in a real life context, so. This makes it easier for them to understand and improves retention of these concepts; encourages student motivation and involvement by relating learning material to their personal experiences. Students tend to be more motivated to understand physical chemistry concepts when they see their relevance to everyday life; helping students develop applicable skills in applying physical chemistry concepts in real life. They can understand how to connect theory with practical situations, thereby gaining a deeper understanding; helping students improve their memory of physical chemistry concepts. The use of real situations makes understanding more concrete and easier to remember; and encouraging students to learn actively through experience, not just passively receiving information. Thus, they can better internalize physical chemistry concepts. By utilizing the CTL-based physical chemistry module, students can experience more meaningful learning, increase understanding of concepts, and be able to apply them contextually in everyday life.

Effectiveness Analysis

The effectiveness test results show that the physical chemistry module based on Contextual Teaching Learning (CTL) is effective in improving students' teaching skills. The results of the achievements obtained in small group trials can be seen in Table 7.

Table 7 shows the scores before and after using the physical chemistry module based on Contextual Teaching Learning (CTL) with the pretest and posttest differences in individual trials and small group trials respectively being 30 and 36.2. The N-gain value in individual trials is in the high criteria, while the N-gain value in small group trials is in the very high criteria.

Table 7. Data on the Effectiveness of Using a Physical Chemistry Module Based on Contextual Teaching Learning (CTL) in Small Group Trials

Trials	The number of students	Average Pretest	Average Postest	N-gain
Individual trials	6	55.8	85.8	0.67
Small group trials	12	56.3	92.5	0.82

The research results produced in this study were higher than research conducted by Ambarwati et al. (2016) which obtained material expert validation results of 74.56% and media experts of 71.38% and practicality obtained through questionnaires of 80.2%. Results the validity aspect obtained from this research was higher at 19.53% and the practicality aspect was higher at 7.3%. In this study, an effectiveness value was produced with an average of 0.67 in individual trials, which was in the high criteria and 0.82 in small group trials, which was in the very high criteria. Several reasons why the physical chemistry module based on Contextual Teaching Learning (CTL) obtains higher validity and practicality results is because the material displayed in the module is taken from various sources such as books and articles, besides that, learning activities are arranged systematically, making it easier for readers to study the module accompanied by step by step instructions.

Conclusion

Based on the research results and discussions that have been described, it can be concluded that the physical chemistry module based on Contextual Teaching Learning (CTL) is suitable for use as teaching material in physical chemistry learning because it meets the validity criteria. The validity of the material aspect is 98.75%, the media is 87.33%, and the language is 98.00%, which is very valid criteria. Practicality based on the student response questionnaire score in individual trials was 95.8% and in small group trials was 89.6%, which is very practical criteria. In this study, an effectiveness value was produced with an average of 0.67 in individual trials, which was in the high criteria and 0.82 in small group trials, which was in the very high criteria.

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Author Contributions

In this research, the author makes a different contribution. The authors have read and approved the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analysis, or interpretation of data; in script writing; or in the decision to publish the results.

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