



# Development of Basic Chemistry II Textbook Based on Research

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**Abstract:** Research based on the absence of the development of quality, innovative and integrated Chemistry textbook with the latest research results that are used to broaden student's horizons and increase student creativity. The purpose of this research is to produce basic Chemistry II textbook based on research. This study uses a type of development research using a 4-D model which consists of 4 stages, namely, definition, design, development and dissemination. The subjects of this study were students of the Department of Chemistry Education of IAIN Batusangkar. The data were collected using a questionnaire. The results of textbook based on research validity obtained a percentage of 88.21% with highly valid category. Then, the results of the practicality test obtained a percentage of 76.31% in the practical category and the results of the effectiveness test showed a significant increase in student activities and learning outcomes. With this, it can be concluded that the basic Chemistry II textbook based on research is valid, practical and effective for use in the learning process

**Keywords:** Practicality; Research; Textbook; Validity

## Introduction

Globalization era requires chemical researchers to be able to carry out experiments in the laboratory in answering all problems or finding new ideas to improve the quality of human life (Sothy et al., 2022). From the results of these experiments, new formulations were obtained in answering problems related to the changes that occur in reaction and discussing the latest findings from the experiments carried out (Schoeller et al., 2018). In addition, the results of experiments in the laboratory can also help in formulating new hypotheses which eventually became guidelines in developing new theories (Chi & Wylie, 2014). The theory was able to become the basis of a field of science or became learning materials in education (Simonson et al., 2019).

In Chemistry, the experimental results are usually published in journals or used as learning materials (Taber, 2018). These materials are used for understanding chemical concepts, the symptoms of reactions that occur, both regarding chemical and

physical changes (Ayyıldız et al., 2022). They can also be used as references in developing the latest inventions. Chemistry learning materials are usually summarized in a textbook that was used during the learning process (Arici et al., 2019). The availability of textbooks at the higher education level is one of the important components in lectures (Tham & Werner, 2005). Quality, innovative and integrated Chemistry textbooks with the results of the latest research are indispensable for students, because they contain information on subject matter as well as explanations of concepts and as a source of ideas in gaining new knowledge. The development of integrated textbooks with experimental results can fulfill quality teaching materials so as to increase student creativity (Hilton, 2016).

Department of Chemistry Education of IAIN Batusangkar was established in 2016. The vision of this department is "Global reputation in Chemistry education that is integrated with research-based Islamic values and local wisdom". When viewed from this vision, it is known that the Department of Chemistry

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Education of IAIN Batusangkar seeks to create educators who have ability in Chemistry education and can integrate it with Islamic values based on research. To achieve this vision, teaching staff in Chemistry education department must use Chemistry textbook based on research that can develop student abilities as prospective educators in accordance with the vision to be achieved.

One of the textbooks used in the learning process at Department of Chemistry Education IAIN Batusangkar, for Basic Chemistry II course, is the book by Syukri S, published by ITB Bandung. The textbook was published in 1999, so the book that students use is an old book. The book only contains standard chemical theories, without linking them to the results of the latest research related to material. Then, the book does not contain experiments related to the material being studied. Indeed, Chemistry is not only learning concepts in class, but there must also be experiments carried out in the laboratory.

Based on the results of interviews with several Chemistry education students, it is known that 80% of students stated that the textbooks they used for learning resources only contained theoretical studies on materials for chemistry and the examples presented were not comprehensive so that they were difficult for students to understand. This condition causes the book to only become a symbol of student compulsory books, and the students look for other books that are more interesting and easier to understand as references during courses. It is very unfortunate, Syukri's textbook can only explain the standard theory of Chemistry, thus causing students to be unable to examine the symptoms in everyday life and the latest discoveries related to Chemistry.

The development of Chemistry textbook based on research is one way that educators can take to improve student learning outcomes. Research-based learning can train students in improving the ability to analyze a concept from activities that have been previously designed. Research-based learning in various teaching materials can help students improve critical, creative and logical thinking skills as well as problem solving skills so as to improve the quality of learning. The use of research-based teaching materials requires students to be independent during learning and thus student's creative skills was formed by themselves during the learning process (Brew & Saunders, 2020; Lambert, 2009). This is an indicator that the inquiry process (finding something) in teaching can be combined and matched with the research domain.

Textbooks based on research are teaching materials that prioritize research in the learning process (Nipa & Kermanshachi, 2020). In this case, the research activities included in the textbook are expressed in two varieties. The first variety is that the provided material creates a situation where students are directed to use the relevant

research achievements of the teacher (or review of research results from other researchers) as part of the teaching materials. At a higher level, a student takes a role and is involved in his teaching research activities. The second variety is material development where teaching and learning activities are developed where the research process or stages are designed to be part or inquiry strategy (Justice et al., 2007).

The advantage of using textbook based on research is to increase the ability to seek a truth from the information that is known (inquiry skills) (Justice et al., 2007). Textbooks based on research provide opportunities for students to not only learn to know the content of teaching materials, but they also have the opportunity to practice searching, formulating hypotheses, collecting and processing data, and drawing conclusions, which can ultimately help them gain a better understanding (Rangkuti, 2017). Students said that the use of textbooks based on research can enhance knowledge about the results of research that has been carried out related to the material being studied (Putro et al., 2016). Textbooks based on research also will be more applicable. In addition, textbook users also get a more contextual description of learning material (Pambudiono et al., 2016). Starting from this background, the authors researcher designs a research entitled, "Development Basic Chemistry II Textbook Based on Research". When compared to other textbooks, this developed textbook provides information on the latest research from scientific journals related to learning materials.

## Method

The method used in this work is a 4-D development model including definition, design, development, and dissemination stage. This research development model was chosen because this model is used as the basis for developing learning tools, the description looks more complete and systematic. It is often used in development research. The definition stage in this research was carried out in several stages, namely (1) interview with chemistry lecturers, (2) analyzing books and teaching materials, (3) literature analysis on chemistry textbooks based on research, (4) analysis of learning objectives, and (5) analysis of student characteristics.

The design stage was carried out by (1) designing a chemistry textbook based on research that contains a) the topic of the activity according to the learning objectives, b) Research-based subject matter and indicators of concept understanding ability, c) Experiments containing the above materials, d) The "Did You Know?" feature, which contains the latest discussed research or the latest information and symptoms in everyday life related to the discussed

material, e) A worksheet that contains questions as a form of evaluation of learning material. (2) Designing research instruments consisting of: a) Basic Chemistry II Textbook Based on Research validation sheet, b) Student response questionnaire validation sheet for Basic Chemistry II Textbook Based on Research, c) Student response questionnaire, d) Student Activity Observation Sheet, and e) Test Question Validation Sheet. At the development stage, the validity, practicality and effectiveness tests were carried out.

The validity test was carried out by validating the basic Chemistry textbook II to 3 validators in the Chemistry field by filling out validation sheet. This validity test is viewed from several aspects, namely, the quality of content and objectives, instructional quality, and technical quality. Validity of basic Chemistry II textbook based on research calculated using the formula:

$$p = \frac{\text{total score}}{\text{maximum score}} \times 100\% \quad (1)$$

Information:

$p$  = percentage of basic Chemistry II textbook validity

**Table 1.** Validity Category

Interval (%)	Category
0-20	Invalid
21-40	Less Valid
41-60	Quite Valid
61-80	Valid
81-100	Highly Valid

Table 1 showed the result of validity category based on aspect provided. Furthermore, the practicality test was carried out with a limited trial in a class, taking basic Chemistry II courses. This trial was conducted to see the practicality or usability of textbooks based on research that have been designed from the aspect of being easy to use, attractive, and efficient.

The practical phase was carried out by filling out response questionnaires by students. Practicality of basic Chemistry II textbook based on research calculated using the formula:

$$p = \frac{\text{total score}}{\text{maximum score}} \times 100\% \quad (2)$$

Information:

$p$  = percentage of basic Chemistry II textbook practicality

Table 2 showed the result of practicality category based on aspect provided.

**Table 2.** Practicality Category

Interval	Category
0-20	Impractical
21-40	Less Practical
41-60	Moderate
61-80	Practical
81-100	Highly Practical

Meanwhile, the effectiveness test design was carried out by comparing the data on student test results before (pre-test) and after (post-test) using textbook based on research. The increase of student test results after using the textbook based on research was calculated by the G Factor formula (N-Gain) (Hake, 1999). First, test the validity of the test questions, the observation sheet and the reliability of the questions. The questions used for the pre-test and post-test in this study were the items that met the valid category. Based on the analysis of the test data, there are 21 questions out of 30 questions that fulfill the valid category that were used to test the effectiveness.

The final stage is the dissemination stage, which is disseminating research products within the scope of national scientific activities as well as book publications and Intellectual Property Rights (IPR)/HKI.

## Result and Discussion

Basic Chemistry II Textbook Based on Research is a teaching material that prioritizes research in the learning process. In this case, the research activities included in the textbook are expressed in two varieties. The first variety is that the provided material creates a situation where students are directed to use the relevant research achievements of the teacher (or review of research results from other researchers) as part of the teaching materials. The second variety is material development, where the development of teaching and learning activities were carried out at the stages of research are designed to be part or strategies in inquiry (find something).

The design of basic Chemistry II textbook based on research is presented in eleven sub-chapters (Mawarnis, 2021), namely: 1) Electrolyte and Nonelectrolyte Solution, 2) Colligative Properties of Solutions, 3) Colloids, 4) Kinetic Theory of Gases, 5) Thermochemistry, 6) Chemical Equilibrium, 7) Solubility and Solution Product, 8) Rate of Reaction, 9) Electrolysis Cell, 10) Galvanic Cell, 11) Radioactive Elements.

The textbook are designed using A4 size paper and Times New Roman font size of 12. The followings are parts of the textbook based on research, namely:

Cover

Cover is the initial appearance of Basic Chemistry II Textbook Based on Research.

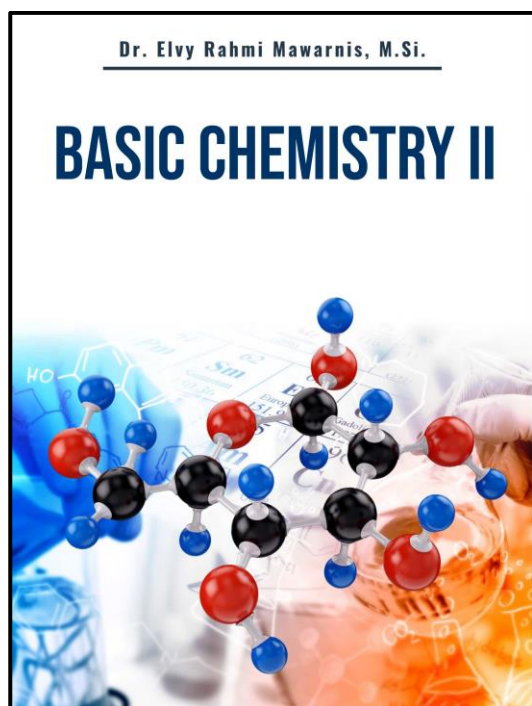


Figure 1. Cover of Textbook

Materials

The designed textbook contains eleven sub-chapters. At the beginning of each chapter, it is equipped with an apperception of the material to be studied.

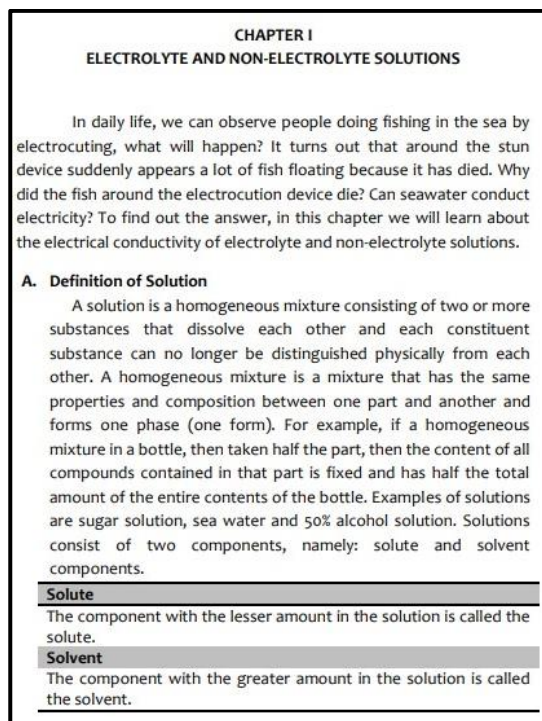


Figure 2. Apperception at the Beginning of Each Chapter

Methodology

The experiment section has been presented

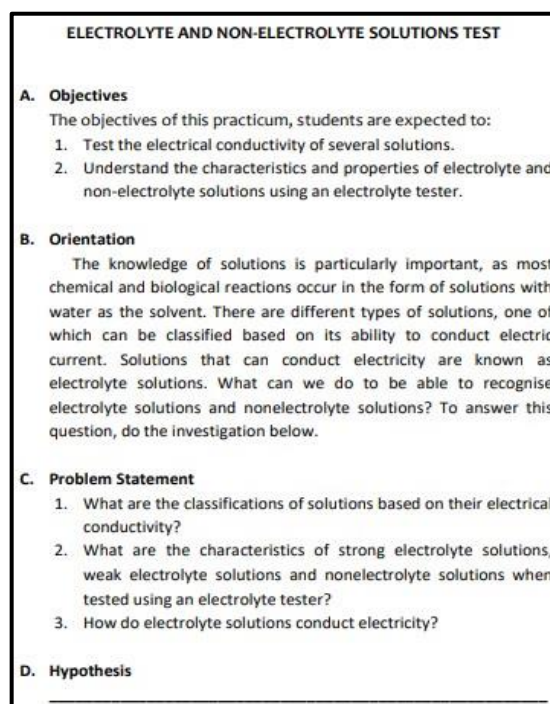


Figure 3. Methodology

“Did You Know?” Feature

“Did you know feature” contains the latest research related to the material and natural phenomena happening around us related to the material being studied.

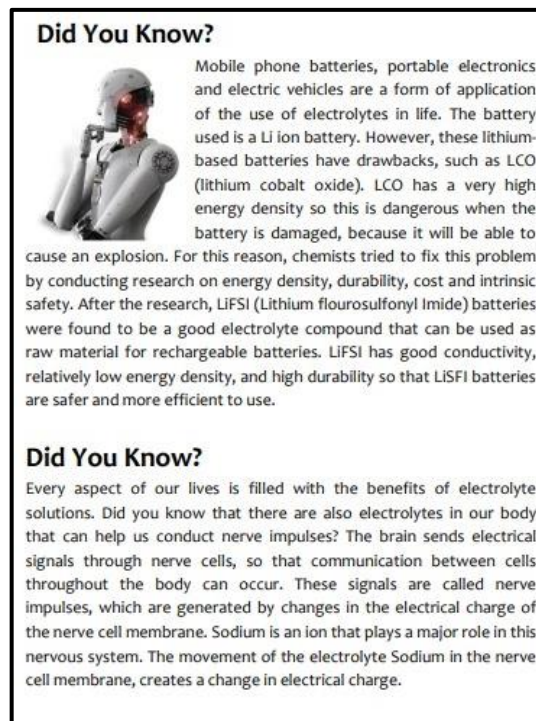


Figure 4. “Did You Know?” Feature

Worksheet

The textbook based on research that was developed presents a worksheet feature that contains questions for evaluating the material.

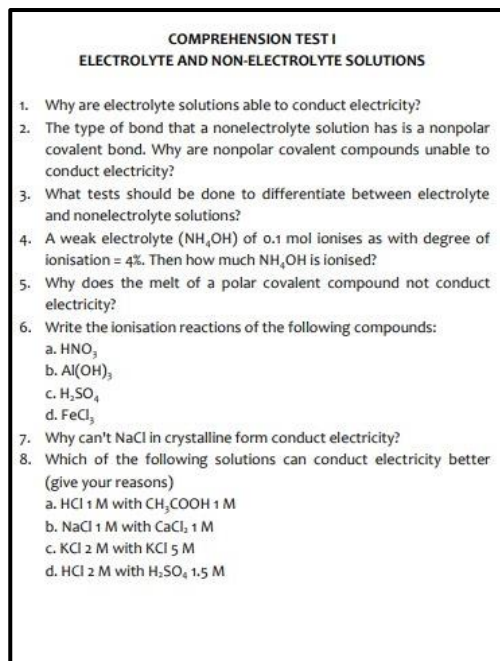


Figure 5. Worksheet

The designed basic Chemistry II textbook based on research has been validated by three experts (validators) and obtained a highly valid category.

Table 3. Data on the Validity of Basic Chemistry II Textbook Based on Research

Aspect	Total Score	Max Score	%	Category
Content Quality and Purpose	95.00	108.00	87.96	Highly Valid
Instructional Quality	121.00	132.00	91.67	Highly Valid
Technical Quality	51.00	60.00	85.00	Highly Valid
Total	267.00	300.00	88.21	Highly Valid

According to Table 3, the results of the validation of the basic Chemistry II textbook Based on Research obtained an average percentage of 88.21%. This percentage states that the basic Chemistry II textbook based on research is categorized as highly valid and has met all three aspects of validation. It can be said that the development of this basic Chemistry II textbook based on research has fulfilled all requirements of its components. In addition, each component has a correlation between one another and is arranged systematically and in accordance with the learning objectives to be achieved. Teaching materials that collect

systematically arranged materials are in fact able to make students understand more about the contents of teaching materials (HB, 2012). In addition, learning materials are related to everyday life. Presentation of information related to the daily environment can encourage curiosity and provide challenges so that students learn more deeply (Larasati et al., 2018).

When viewed from the textbooks that have been developed, it presents the materials such as questions and discussion that are very easy to understand by the students. In addition, there are simple experiments that can help students understand the material being taught. According to Hamidiyah, experiments train students to be able to find out for themselves various concepts that are studied thoroughly (Hamidiyah, 2017). The most important thing is the provision of experimental activities designed in accordance with the availability of chemicals at IAIN Batusangkar. It is important for students to know is information regarding the latest research related to the discussed materials. This will increase students' insight, level of thinking and ability in studying the symptoms of chemical changes that occur in environment.

In this study also carried out the practical stage. The purpose of this practicality stage is to find out how students respond to the textbooks that have been developed.

Table 4. Student Response Questionnaire Data on Basic Chemistry II Textbook Based on Research

Aspect	Total Score	Max score	%	Category
Easy to use	338.00	448.00	75.45	Practical
Attractive	171.00	224.00	76.34	Practical
Efficient	132.00	168.00	78.57	Practical
Total	641.00	840.00	76.31	Practical

It can be seen that the basic Chemistry II textbook based on research is categorized as practical with an overall average of 76.31% as shown in Table 4. This is in accordance with Riduwan's opinion, which states that the range of values is between 61% -80%, including the practical category (Riduwan, 2008). It can be said that basic Chemistry II textbook based on research is easy to understand by the students because the material is systematically arranged and the questions are presented clearly and in accordance with learning outcomes. Then, in terms of textbook based on research design, it is quite attractive. One thing that must be understood is that a good book design will be able to give a good impression to the students who read the book, so that it is able to attract student's interest in learning (Ratih & Hakim, 2018).

The final step was to test the effectiveness using only one class to be used as a research sample, namely,

by comparing the initial test (pre-test) and the final test (post-test) of students. The data from this research are in the form: 1) learning activity data obtained from observation sheets and 2) learning outcomes test data.

#### *Student Learning Activities*

The activity data were obtained from learning activity observation sheets. The observations were made 6 times that were on March 4, March 11, March 18, March 25, April 1 and April 8 as illustrated in Table 5. This observation took place in the class during the lecture which was carried out for six meetings with four observed indicators, namely: 1) learning activity, 2) learning independence, 3) ability to ask questions and 4) ability to express ideas or opinions. When viewed from the test score obtained from observing student activities,

it was seen that there was an increase for each meeting. The obtained results are classified as quite high category. This proves that the assessment aspects regarding student learning activities using basic Chemistry II textbook based on research have been fulfilled.

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**Table 5.** Test Scores on Student Learning Activities

Student attendance number	Meeting					
	1	2	3	4	5	6
1	43.70	56.25	62.50	68.75	75.00	87.50
2	37.50	50.00	50.00	56.25	68.75	87.50
3	37.50	43.75	50.00	62.50	68.75	81.25
4	31.50	37.50	43.75	56.25	62.50	75.00
5	31.50	43.75	56.25	56.25	62.50	75.00
6	43.75	62.50	68.75	75.00	87.50	93.75
7	31.25	56.25	62.50	68.75	81.25	87.50
8	25.00	31.25	37.50	43.75	62.50	68.75
9	31.50	37.50	50.00	56.25	75.00	87.50
10	37.50	50.00	56.25	68.75	75.00	93.75
11	37.50	56.25	68.75	68.75	75.00	93.75
12	25.00	37.25	56.25	56.25	68.75	75.00
13	25.00	31.50	43.75	50.00	62.50	75.00
14	31.25	43.75	50.00	56.25	68.75	81.25
15	43.75	50.00	62.50	68.75	81.25	81.25
Avg score	34.21	45.83	54.58	60.83	71.67	82.92

The first aspect of the assessment that has been carried out was learning activity. On the observation sheet, it can be seen that the test score of student activities continues to increase until the 6<sup>th</sup> meeting. This is because the basic Chemistry II research textbook does not only contain monotonous material but is accompanied by applications of lecture material in life and is directly presented in practical activities related to the material being studied and compiled with the inquiry method syntax. The inquiry method is a method that emphasizes student activities maximally to seek to find out the meaning and concepts of the material being studied. Students not only act as recipients but play their own roles to find the essence of the material being studied (Septiani & Susanti, 2021). The inquiry syntax used in the practicum steps is orientation, problem formulation, hypothesis, collecting data and drawing conclusions. So, it can be said that by using this inquiry method, students are required to find out and solve their

own problems related to the lecture material being studied, so that this allows students to play an active role in courses, especially when students carry out practicum in the laboratory.

The second aspect is learning independence. When viewed on the student activity observation sheet, the assessment of student learning independence also increased from the first meeting to the sixth meeting. This is because basic Chemistry II textbook based on research contains the latest research that is displayed in each chapter of the lecture material. This makes the students do not get bored reading the textbook. In addition, the textbook is equipped with an understanding test in the form of practice questions that can be done directly by students during the learning process.

Furthermore, the third and fourth aspects, namely, the ability to ask questions and to express ideas or opinions also received increasing test scores in six

meetings. This is because basic Chemistry II textbook based on research contains many features such as “Did you know?” which contains interesting information and the latest research on the material discussed during courses. This feature can increase student insight which causes students to be interested and dig deeper into the information obtained by asking lecturers or discussing with other students.

*Classical Completeness*

Based on the final ability test (post-test) conducted by students after meetings (3 times with online meetings and 3 times with face-to-face meetings) using basic Chemistry II textbook based on research, the following results are obtained and shown in Table 6.

**Table 6.** Final Ability Test Results

Test Results	Value
N	14.00
Average	85.03
Max.	95.23
Min.	80.95

Information:

N = Number of students

Average = Average student score

Max. = Highest score

Min. = lowest score

Classical completeness is calculated using the formula:

$$p = \frac{\text{many students have completed}}{\text{many students take the test}} \times 100\% \quad (3)$$

Information:

p = percentage of student learning completeness classically

According to Mulyasa, classical completeness can be said to have completed learning, if in that class there

are 85% of students who completed learning (Mulyasa, 2002). A teaching material is said to be effective if in the class, there are 85% of students who have completed their studies, while the minimum completeness that must be obtained by students is 75, so:

$$p = \frac{\text{many students have completed}}{\text{many students take the test}} \times 100\%$$

$$p = \frac{14}{14} \times 100\%$$

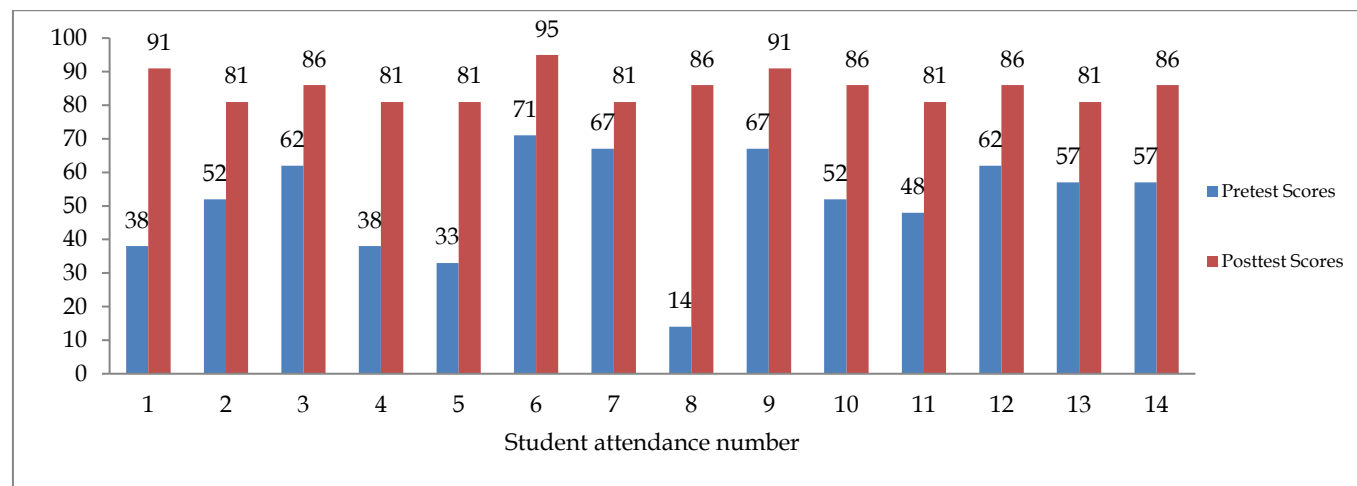
$$p = 100\%$$

One of the factors that influence student grades is the existence of teaching materials that become literature and practice questions for students. Good teaching materials are certainly teaching materials that can increase student interest and motivation in learning so as to ensure the continuity of learning activities and provide direction to learning activities so that learning objectives can be achieved (Nurdyansyah, 2018).

Based on the data analysis that has been done, it can be seen that the average post-test score is 85.03. While the percentage of student’s classical completeness is 100%. Completeness of these student scores can be achieved because in basic Chemistry II courses, students learn to use basic Chemistry II textbook based on research. This textbook contains not only monotonous material but is accompanied by applications in life, research and provides features that contain the latest information and inquiry-based practicum related to the discussed material.

*Analysis of learning outcomes*

After the initial ability test (pre-test) and final ability test (post-test) were carried out, the student’s learning outcomes were obtained. The comparison of the pre-test and post-test scores of student learning outcomes can be seen in detail in Figure 9.



**Figure 9.** Comparison of Pre-test and Post-test Scores

It can be seen from Table 7 that the post-test scores of Chemistry education students after using basic Chemistry II textbook based on research have increased. The highest increase in learning outcomes was experienced by student number 6. After obtaining the pre-test and post-test scores for learning outcomes, then the two test results were compared by looking for normal gain (N-gain).

**Table 7.** N-Gain Normality Test Results

Student attendance number	Pre-test Scores	Post-test Scores	N-Gain
1	38.09	90.47	0.85
2	52.38	80.95	0.60
3	61.90	85.71	0.62
4	38.09	80.95	0.80
5	33.33	80.95	0.71
6	71.42	95.23	0.83
7	66.66	80.95	0.43
8	14.28	85.71	0.83
9	66.66	90.47	0.71
10	52.38	85.71	0.70
11	47.61	80.95	0.64
12	61.90	85.71	0.62
13	57.14	80.95	0.56
14	57.14	85.71	0.67
Avg	48.85	85.03	0.68

An overview of student learning outcomes using basic Chemistry II textbook based on research was obtained from the learning outcomes test, namely, the results of the initial ability test (pre-test) and final ability test (post-test). Based on the results of data processing, the student's pre-test average score was 48.85 (100 scale), while the post-test average value was 85.03 (100 scale). It can be seen that there has been an increase in student learning outcomes after using basic Chemistry II textbook based on research. After the normalized N-Gain assessment was carried out, the N-Gain value of 0.684 was obtained which was in the medium category. From the N-Gain value data, it can be stated that basic Chemistry II lecture activities using textbook based on research are included in the effective category, especially for student learning outcomes that tend to increase.

The dissemination stage was the last stage after the product met the validity, practicality, and effectiveness requirements (Fatahillah et al., 2021). The dissemination stage aims to publish or promote products that researchers have developed (Ramdani et al., 2021). The dissemination stage is the stage of using a product that has been developed on a scale for example in other classes, at other universities, and by other lecturers (Mariyani et al., 2022). This stage was carried out by publishing textbook through publishing digital textbook with ISBN and registering research products with

Intellectual Property Rights (HKI) (Ramdani et al., 2021). The dissemination stage was done by publishing basic Chemistry II textbook based on research to publisher, deepublish. Product are also uploaded to the google play store, link [https://play.google.com/store/books/details/Dr\\_Elvy\\_Rahmi\\_Mawarnis\\_Kimia\\_Dasar\\_II?id=ooEnEAAAQBAJ](https://play.google.com/store/books/details/Dr_Elvy_Rahmi_Mawarnis_Kimia_Dasar_II?id=ooEnEAAAQBAJ). This book can be widely used by students who study basic.

## Conclusion

Based on the research conducted, basic Chemistry II textbook based on research is classified as highly valid based on the assessment of 3 validators. This is viewed from several aspects, namely, the quality of content and objectives, instructional quality, and technical quality with an overall percentage of 87.96%. The results of the trial were limited to 14 students who were taking the second basic Chemistry course. The textbook was practical in terms of easy-to-use, attractive, and efficient aspects with a percentage of 75.51%. Student activities in basic Chemistry II courses using basic Chemistry II textbook based on research are categorized as quite high because there is an increase in student activity at each meeting. Student learning outcomes have increased after using basic Chemistry II textbook based on research as evidenced by the N-Gain value of 0.68 which is in the medium category. As a conclusion, basic Chemistry II textbook based on research is effective the learning process.

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