Developing Web-based Active Tutorial Model to Enhance Students’ Critical Thinking and Learning Community

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Abstract. This study aims to develop web-based active tutorial model in Basic Chemistry subject to enhance critical thinking and learning community of students as prospective chemistry teachers. This development research consists of define, design, develop, and disseminate steps and utilizes instruments namely questionnaires, validation sheets, interview guidelines, field records, observation sheets, and test. It produces Chemwebs instructional material which has been tested for its validity, practicality, and effectiveness. This product is categorized as valid based on expert reviews with an average score of 4.22. Product’s practicality in one-to-one evaluation is 4.01 while in small-group testing is 4.30. Field test results show that this product is effective to enhance students’ learning outcomes and improve their critical thinking skills noticed from gain-score of its indicators which is about 0.6. Students also tend to be active in learning community and discuss topics contained in this product inside and outside classroom.

1. Introduction

Basic Chemistry studies Stoichiometry, Thermodynamics, Redox Reactions, Chemical Equilibrium, Chemical Bonding and Molecular Geometry, Kinetics, Biochemistry, Carbon Chemistry, Elemental Chemistry, and Colloid. This course provides in-depth knowledge of chemistry by developing skills in the subject matter of Basic Chemistry. Learning approach is directed more at developing students’ intellectual skills in constructing and reproducing the concepts they have learned. Analysis results of the weaknesses in the Basic Chemistry lectures shows that lecture process that has taken place so far has not been able to accommodate the needs of students in an effort to achieve the expected quality of learning, as well as to develop nurturant effects to help develop attitudes and personality of students as prospective teachers. Moreover, lecturers tend to apply discussion and direct instruction as their learning methods.

Learning paradigm changing is not only about curriculum content, but also pedagogy. Lecturer can manipulate learning method in order to improve the quality of learning [8]. A learning outcome requires different internal and external learning conditions [4]. Students need authentic learning experiences stimulate students' critical thinking skills. Critical thinking is an evaluative activity to produce a result [3]. Critical thinking is a complex process that involves receiving and confirming, analyzing, and evaluating data by considering qualitative and quantitative aspects, as well as selecting or making decision based on evaluation results [5]. Critical thinking is needed in order to solve a problem with appropriate results.
A computer-based tutorial strategy is a choice in order to develop students’ critical thinking skills and the learning community as well as to improve students’ understanding of basic chemistry learning. The use of web-based tutorial is very effective in teaching a topic of analysis of human body composition [2]. Computer-based tutorials are very helpful for students in acquiring more effective and efficient knowledge [6]. Lajoie & Derry mentions one way that can be used to strengthen learning and thinking is the use of computer technology as a cognitive tool [1]. Similarly, students’ ability in terms of higher-order thinking skills shows an increase when technology is integrated in learning process [7].

The ability to think critically is crucial to create reliable prospective chemistry teachers. As a consequence, universities should improve learning system to achieve this goal. This study will result a teachable and accessible web-based basic chemistry lecture system to foster critical thinking skills and develop learning community as a media to reconstruct and comprehend chemical basic concepts required for advanced chemistry learning. This type of teaching materials will alleviate student difficulties in constructing basic chemical concepts as well as overcome misconceptions that might be happened in learning process. Moreover, it can help students to involve in meaningful learning to achieve competence or life skills. Also, this web-based system can be a reference for Basic Chemistry lecturers and impede teacher-centered learning.

2. Method
This research aims to develop web-based active tutorial model in Basic Chemistry subject to enhance critical thinking and learning community of students as prospective chemistry teachers by following to development research model proposed by Thiagarajan et al. [10] which consists of four steps: define, design, develop, and disseminate (known as 4D Model) combined with Tessmer [9]. Thinking framework of this development research can be seen in figure 1.

![Thinking framework of research development](image-url)
The define stage includes literature review and field study, curriculum analysis, analysis of learning resources, analysis of students’ characteristics, and instructional materials selection. The design step includes a) selecting basic chemistry materials while analyzing the concept, b) designing a lecture system with a web-based active tutorial model in order to foster critical thinking and a learning community, and c) development of research instruments in the form of evaluation instruments to be used by expert review (content, design, technical quality), students for one-to-one (misconception, language clarity and instructions), and multiple choice test, interview guidelines, observation sheets, questionnaires for both lecturers and students. The develop stage applies Tessmer’s Formative Evaluation which includes the step of self-evaluation, expert review, one to one, small group, and field test. A detailed procedure of this web-based active tutorial model can be seen in figure 2.

The data obtained during the study will be analyzed qualitatively and quantitatively. Qualitative descriptive analysis will be used to analyze the practicality of a developed-web-based active tutorial model obtained from validation results on expert review, questionnaire findings on one-to-one and small group evaluation, and observations findings on field test. Moreover this analysis will describe the strengths and the weaknesses of a developed-model and students’ difficulties in understanding the direction and guidance contained in developed-model. Quantitative descriptive analysis will be employed to analyze data derived from expert review, observation, questionnaire and test.
3. Results
Data from define stage show that students who took basic chemistry course were coming from districts or regions and experienced teacher-centered learning and seldom conducted lab work. Material analysis was conducted by using some chemistry textbooks and then continued by interviewing colleagues who taught Basic chemistry in another study program. Design stage involved teaching materials and web designs. When designing teaching materials, content were derived from macro to micro. The web design used Moodle where the stages were made by adopting the program in Moodle and adding some features. This web design allowed students to have their own password and joined in a group of 6-7 people. Each group chose the group leader who will be assigned as a mentor in the group. When they studied in the classroom, they remained in a group and can discuss outside the tutorial system. Group discussion can be monitored in the program so lecturers can control the activity between groups and each task was sent by online.

3.1. Expert review
There are three aspects which need to be reviewed by experts namely content, design, and critical thinking aspects. Besides giving an assessment, experts also provided comments and suggestions. Comments and suggestions from experts were included as revision to the developed teaching materials. Before making a revision, the researcher discussed in advance whether suggestions from experts was accepted or not. Expert review results show that this teaching material is valid with score of 4.22. Example of comments and suggestions from content experts can be seen in table 1.
Experts gave comments and suggestions related to teaching material design which can be seen in Table 2.

**Table 1. Comments and suggestions from content experts**

| No. | Suggestion                                                                 | Before Revision                                                                 | After Revision                                                                 |
|-----|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 1   | Examples of rate of reaction are adjusted to student residence so that students are easier to understand | ![Image of a table showing different concentrations of NO and Cl2](image) | ![Image of a table showing different concentrations of NO and Cl2](image) |
| 2   | There is a mistake in writing chlorine gas symbol                            |                                                                                |                                                                                |
| 3   | Wrong examples for organic and inorganic catalysts                          |                                                                                |                                                                                |

Experts gave comments and suggestions related to critical thinking aspect which can be seen in Table 3.

**Table 2. Comments and suggestions from design experts**

| Suggestion                                                                 | Before Revision                                                                 | After Revision                                                                 |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Add instruction for using teaching material in the form of PDF files       | ![Image of instructions for using teaching material](image)                  | ![Image of instructions for using teaching material](image)                  |

Experts gave comments and suggestions related to critical thinking aspect which can be seen in Table 3.

**Table 3. Comments and suggestions from critical thinking experts**

| Suggestion                                                                 | Before Revision                                                                 | After Revision                                                                 |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Give more questions or evaluation in teaching material                     | ![Image of questions and answers](image)                                        | ![Image of questions and answers](image)                                        |
3.2. One-to-one evaluation
This stage involved three students who took Basic Chemistry I course. They used this teaching material and evaluated its practicality and gave suggestion related to its learning instruction, figures composition, and content. The average score for this stage is 4.01. Suggestions from students can be seen in table 4.

| Suggestion                        | Before Revision | After Revision |
|-----------------------------------|-----------------|----------------|
| Add more explanation about rate of reaction | Kinetics Clima Dalam pokok bahasan Kinetik Kimia materi-materi yang akan diperlapai adalah Persamaan Laju Reaksi, Orde Reaksi, dan Faktor-faktor Penentu Laju Reaksi Berdasarkan Teori Tumbukan 1. Masalah mampu menjasahkan laju reaksi. 2. Masalah mampu menentukan persamaan laju reaksi. 3. Masalah mampu menentukan orde reaksi. 4. Masalah mampu menjasahkan faktor-faktor penentu laju reaksi berdasarkan teori tumbukan. Sebelum anda mengarsipasi kinektik kimia, silahkan baca langsung langkah pemeliharaan menggunakan molder pada file berikut. | Kinetics Clima Dalam pokok bahasan Kinetik Kimia materi-materi yang akan diperlapai adalah Persamaan Laju Reaksi, Orde Reaksi, dan Faktor-faktor Penentu Laju Reaksi Berdasarkan Teori Tumbukan 1. Masalah mampu menjasahkan laju reaksi. 2. Masalah mampu menentukan persamaan laju reaksi. 3. Masalah mampu menentukan orde reaksi. 4. Masalah mampu menjasahkan faktor-faktor penentu laju reaksi berdasarkan teori tumbukan. Sebelum anda mengarsipasi kinektik kimia, silahkan baca langsung langkah pemeliharaan menggunakan molder pada file berikut. |
| Fix size of pictures             |                 | Lokasi Reaksi | Gambar 10.1 Nilai yang sedang melaju |

3.3. Small group evaluation
This evaluation still focused on teaching material and web practicality which involved 8 Chemistry Education Study Program students. Average score for this evaluation is 4.30 and student suggestions can be seen in table 5. After this evaluation, teaching material and web were revised in order to be utilized by students in field test to find out its effectiveness.

| Suggestion                        | Before Revision | After Revision |
|-----------------------------------|-----------------|----------------|
| Need to add box and color for chemical equation | Pada umumnya hubungan antara laju reaksi dengan konversi zat-zat reaksi berlaku dinamakan dengan data depan dari formula. Bilangan pengurang yang menyatakan hubungan konversi antara laju reaksi disebut konsentrasi. Untuk rumus A + B → C + D permasalahan laju reaksi dirumuskan: | Pada umumnya hubungan antara laju reaksi dengan konversi zat-zat reaksi berlaku dinamakan dengan data depan dari formula. Bilangan pengurang yang menyatakan hubungan konversi antara laju reaksi disebut konsentrasi. Untuk rumus A + B → C + D permasalahan laju reaksi dirumuskan: |

3.4. Field test
This stage conducted through experiment research. Students were divided into 2 groups, control and experimental groups. Control group used their ordinary teaching material while the experimental one utilized web-based active tutorial model. Both learning outcomes are not quite different about 19.40%. Students’ activity in discussing topics in web-based active tutorial were also observed. Observation results show that their activities were quite high especially in discussion view. Example of the activity of group 1 can be seen in table 6.
### Table 6. Intensity of students for rate of reaction topic

| No | Name of Students             | Forum View | Forum add post | Discussion View | Discussion Update | Total | %    |
|----|------------------------------|------------|----------------|-----------------|-------------------|-------|------|
|    |                              |            |                |                 |                   |       |      |
| 1  | Septi Andriani               | 2          | 1              | 6               | 0                 | 9     | 1.88%|
| 2  | Nurul Hakima                 | 1          | 1              | 2               | 0                 | 4     | 0.84%|
| 3  | Ahmad Irfan                  | 9          | 1              | 8               | 3                 | 21    | 4.39%|
| 4  | Diah Permata                 | 1          | 1              | 2               | 0                 | 4     | 0.84%|
|    |                              |            |                |                 |                   |       |      |
|    |                              |            |                |                 |                   |       |      |
| 1  | Arif Fardillah               | 4          | 1              | 3               | 0                 | 8     | 1.67%|
| 2  | Ria Astuti                   | 7          | 3              | 9               | 0                 | 19    | 3.97%|
| 3  | Rika Sulastri                | 2          | 2              | 4               | 0                 | 8     | 1.67%|
| 4  | Yuli Ana                     | 6          | 1              | 7               | 0                 | 14    | 2.93%|
|    |                              |            |                |                 |                   |       |      |
|    |                              |            |                |                 |                   |       |      |
| 1  | Anadia Mutiara               | 1          | 1              | 2               | 0                 | 4     | 0.84%|
| 2  | Dess Kasturi                 | 4          | 2              | 5               | 0                 | 11    | 2.30%|
| 3  | Indri Permata                | 1          | 1              | 2               | 0                 | 4     | 0.84%|
| 4  | Liza Susila                  | 2          | 1              | 4               | 0                 | 7     | 1.46%|
| 5  | Meti Triany                  | 7          | 2              | 11              | 0                 | 20    | 4.18%|
|    |                              |            |                |                 |                   |       |      |
|    |                              |            |                |                 |                   |       |      |
| 1  | Fitri Yanti                  | 3          | 1              | 8               | 0                 | 12    | 2.51%|
| 2  | Maya Elfiani                 | 6          | 3              | 14              | 3                 | 26    | 5.44%|
| 3  | Reni Octavia                 | 4          | 1              | 5               | 0                 | 10    | 2.09%|
| 4  | Ferdya Orinmas               | 2          | 1              | 4               | 0                 | 7     | 1.46%|
| 5  | Reni Marzela                 | 2          | 1              | 4               | 0                 | 7     | 1.46%|
|    |                              |            |                |                 |                   |       |      |
|    |                              |            |                |                 |                   |       |      |
| 1  | Hasanul Kamil                | 7          | 1              | 6               | 0                 | 14    | 2.93%|
| 2  | Eka Ranti                    | 2          | 1              | 4               | 0                 | 7     | 1.46%|
| 3  | Indri savitri                | 4          | 1              | 4               | 0                 | 9     | 1.88%|
|    |                              |            |                |                 |                   |       |      |
|    |                              |            |                |                 |                   |       |      |
| 1  | Lusiana Setiawati            | 6          | 4              | 7               | 0                 | 17    | 3.56%|
| 2  | Devi komala                  | 3          | 4              | 11              | 1                 | 19    | 3.97%|
| 3  | Elzi elziyana                | 6          | 5              | 9               | 0                 | 20    | 4.18%|
| 4  | Yulin Oktariani              | 3          | 4              | 10              | 2                 | 19    | 3.97%|

### 4. Discussion

Product of this study is in the form of web-based active tutorial material which can be accessed through ChemWebs. At define stage, students’ character and qualification have been assessed through questionnaires and interview. Data show that there were 84 students which consisted of 34 students accepted through SNMPTN, 20 students accepted through SBMPTN and 30 students entered through USM. Also, students’ activities were still low in terms of learning system and group collaboration as well as their motivation in terms of learning preparation and initiative. They encountered difficulties to comprehend concepts, laws, principals, and basic chemistry calculation and causing low learning outcomes and critical thinking skills. Analyzing chemistry textbooks were also conducted in this stage. Data shown that textbooks are self contained meaning that all learning material from one competency unit or sub competency is presented as a whole, packaged in small units and thorough, and provided with clear examples and illustrations, practice questions, assignments. However, this books are not self instructional, do not contain latest and contextual material, and use complex and uncommunicative language. Also, there is no material resume, evaluation instrument, and feedback. Furthermore, students were not interested in learning chemistry textbooks because of language difficulty and less attractive appearance.
Formulating and compiling a syllabus of web-based active tutorial model and determining web application program were conducted in the next step (design). Web application program should facilitate presentation of information, question of responses, judging of responses, providing feedback about responses, remediation, and sequencing lesson segment. Web application program in accordance with those criteria is Moodle 2.5.1.

All learning materials have been uploaded on the web, so students who take basic chemistry or anyone who are interested in studying basic chemistry. There were some difficulties in generating topics from macro to micro because must notice syllabus and lesson plan. Also, learning material should be designed by considering students’ critical thinking. It can be assumed that students’ critical thinking can be improved when the C3 domain questions are developed, for example, why does the reddish color on the sky appear at sunrise? When they answer color affects the wavelength, we can strengthen our question with the angle of reflection and the number of particles near the surface of the earth.

Students were provided with problems followed by questions and they needed to discuss about it in order to get the best answer. Each student has obligation to answer one question and discuss it with his peers so all of group members will understand the process to solve this question. During discussion students used various chemistry textbooks and material from the internet. After discussion, students were given exercise that they had to answer independently. Then, the lecturer and students discussed it. The appearance of web-based active tutorial model can be seen in figure 3 and 4.

There are five topics provided in this teaching material namely rate of reaction, colloid, redox reaction, elemental chemistry and carbon chemistry (see figure 5). All topics can be accessed by students who take basic chemistry. All topics are equipped with time allocation, basic competencies, learning indicators, learning instruction, name of teacher, list of subtopics, topic outline, animation and exercise.
Development stage consists of expert review, one-to-one evaluation, small group evaluation and field test. Scores gained from evaluation of the first three show that the web-based active tutorial model is categorized valid and practical to be utilized for further trial, field test. In content validation, experts suggested to adjust example of rate of reaction with students’ residence. This suggestion was accepted and improvements have been made to teaching material. Before revision, the example of rate of reaction is when we drive a car from Jember to Surabaya. After revision, Jember city was replaced with Palembang city and Surabaya city was replaced with Baturaja city. The next comment is that there is a mistake in writing chlorine gas. Before revision, chemical symbol for chlorine gas was Cl₂, after revision, this symbol becomes Cl₂. Another comment related to group the types of catalysts. Before revision, V₂O₅, Pt, Ni, Pb, Alumina and silica gel were example of organic catalysts and renin, enzyme from yeast, and trypsin were categorized as inorganic catalysts. Then, this classification has been corrected by exchanging both example of catalysts. The correct organic catalysts are renin, enzyme from yeast, and trypsin and inorganic catalysts are V₂O₅, Pt, Ni, Pb, Alumina and silica gel.

Experts regarded the design of web-based active tutorial was appropriate to be utilized as chemistry teaching material. However, it is necessary to add more learning instructions or steps to use this teaching material on the front page of web. This suggestion was received and learning instruction was added.

Experts of critical thinking advised to add questions in this teaching material to foster student thinking skills. The questions will encourage students to find problem solution. Advice from experts of critical thinking was accepted and improvements have been made. Before revision, web-based active tutorial only contained material explanation without question or exercise. For example, students were given table of rate of reaction between NO and Cl₂. Under the table, students were given directly given an explanation as follows: from the first and second experiments, when [Cl₂] is made twice and [NO] is constant, the reaction rate will be doubled from before. From this explanation, students were immediately informed. Therefore after revision the explanation was replaced by questions: how much is the initial rate of reaction? From these questions students will think how to answer this question.

One-to-one evaluation was carried out by three students consisting of high, medium and low ability of students. The three students gave assessments, comments and suggestions on teaching materials through questionnaire. Student commented that font size of web front page is appropriate, the legibility of the writing is still unclear because the explanation of rate of reaction is unreadable, subject matter and sub-subject matter explanation are understandable, the color composition should be made more interesting. Revision has been made like changing text alignment from justify to align text left so the writing can be read clearly. Next comments related to learning instruction were good in terms of the appropriateness of font size, the readability of writing, well color composition, and understandable learning directions so no improvements were made to the teaching material. The appearance of sub-topic was good in terms of the appropriateness of font size, the readability of text, well color composition, and clear of sub-subject matter presentation. For the appearance of content, not only the font size and color composition were appropriate but also the readability of text was clear but the
image should be enlarged. A revision has been made related to image size so the explanation below image can be read clearly by students. There were comments related to video displayed in sub-topic of determining rate of reaction based on the collision theory. The sound of video is too poor and video about bomb blast is too fast. However, there was no revision related to these because the video could not be edited. The average score obtained in one-to-one evaluation is 4.01.

The small group evaluation was carried out by eight students consisting of high, medium and low ability of students. The eight students assessed teaching materials through questionnaires and gave comments and suggestions on teaching material. Comments and suggestions from eight students were used as a basis for revising teaching material before being used in the field test. Students commented that this web is good, easy to understand, and interesting, but it would be better if the chemistry equations were colorful and put in border. The revised teaching material from this evaluation has the average score about 4.30.

In the field test, students’ critical thinking is improved proven by the average score of critical thinking indicators about 0.6 which is categorized in medium level. Collaboration between students and groups is quite high forming a good learning community. Students tend to learn inside and outside classroom and their learning activity can be observed through this web (see figure 6).

![Figure 6. Example of two groups activities utilizing web-based active tutorial model](image)

5. Conclusion

This web-based active tutorial model is categorized as valid based on expert reviews with an average score of 4.22. Product’s practicality in one-to-one evaluation is 4.01 while in small-group testing is 4.30. Field test results show that this product is effective to enhance students’ learning outcomes and improve their critical thinking skills noticed from gain-score (0.6) of its indicators which is about 0.6. Students also tend to be active in learning community and discuss topics contained in this product inside and outside classroom.

6. References

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