Designing metacognitive chemical reading: A stimulant for chemistry problem posing

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Designing metacognitive chemical reading: A stimulant for chemistry problem posing

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Abstract. An investigation has been conducted to find the criteria of a metacognitive chemical reading for stimulating a chemical problem posing activity. A number of twenty undergraduate students on chemistry education has joined voluntarily to this study. Two chemical articles on the application of the chemical equilibrium topic were designed based on some characteristics toward article structures, tetrahedral of chemistry education (the humanistic approach in a new paradigm of chemistry education), and the properties of a scientific reading. A think-aloud protocol was conducted to reveal the students’ metacognitive behaviours during chemical reading activity. Transcriptions of the activities were analysed in sentence by sentence to find the specific metacognitive behaviours on each sentence. A measurement to the reading speed was conducted for seeking the reading pattern on chemical reading activities. Through a phenomenological reduction method all metacognitive expressions were interpreted to the chemical reading parameters for stimulating the chemical problem posing. This study indicated that the dependent multi-representations have enhanced the interest, the metacognitive expression, and the thinking process of students. Moreover, the findings showed that the specific locations of the chemical representations, the reading speed spent by considering the chemical understanding, the maximum words for chemical reading activity, the time allocation for the chemical representation, and the chemical reading properties contributed the metacognitive chemical reading activities.

1. Introduction
Since the focuses of 21st century learning and innovation skills are creativity and innovation, critical learning and problem solving, communication, and collaboration [1-2], the combination of skills and the multifaceted chemistry teaching and learning must become unseparated unification. New concepts of how the world works must be built and constructed into the common-sense of future generations in order to justify needed science-related expenditures. Chemistry educators can and should make major contributions to this urgently important shift in the popular idea of nature [3]. Chemistry educators should do well to make their students aware of the philosophical puzzle of laws of nature, since in doing so they reveal how the body of knowledge presented to them in chemistry teaching is often presented in a historically biased and contingent way [4]. These demands could be transferred to chemistry learners through stimulating them to think in a metacognitive level.

Chemical reading should be arranged to stimulating higher ordered thinking of the students in this emphasizing science literacy era. At least, there are four aspects that should be considered to design a chemical reading for transcribing the chemical knowledge to readers. They are the structure of the
reading, chemistry multiple representations, humanistic approach in chemistry education, and metacognitive reading characteristic. The first can be considered as article of chemistry. It should determine the length of the article, type of the article, task demand, and interdisciplinary level [5]. A short article was considered up to four-hundred words. The type of article should give an integrated complex information. The task demanded should be in a specific chemical context and need various thinking skills and chemical aspects.

The second, the basic chemistry multiple-representative consisted of four representatives that should be considered in every chemical reading. They are phenomenology or macro, model or particulate/sub-microscopic, symbol, and process aspects [6-9]. The phenomenology aspect is the phenomena representative of an experience got through the senses that consist of clear empirical properties of laboratory and daily life and could be measured. The model aspect is seeking a qualitative explanation towards the phenomena and modelling the sub-microscale things such as geometry molecule. The symbolic aspect is seeking for a quantitative explanation of phenomena including all conventions in chemistry, related to the phenomenology as a stoichiometric computation and to the model as a description of chemical and physical changes during reactions. The process aspect is how to understand the way of interactions of matters [9]. These four representations should be included or may be integrated on every chemical reading because they acted as chemical languages that directed to emphasize the scientific literacy, or in chemistry called by metavisual [6, 10]. The problem is how to present the all representation to our students, particularly in sub-microscopic aspect. Not only for students, but also for teachers, the world of sub-microscopic is very challenges and need to be more concerning. There is a need for clear understanding of the conventions and styles of molecular representations and therefore the teaching of these conventions [11]. Without such an understanding, students cannot visualize spatial and structural features of a molecule nor consider implications of these features on reactivity.

The third is the humanistic approach in chemistry education that has three levels: techno-science, contextual, and critical level [12-15]. Science in technology or its application promoted techno-science and technical-instrumental training, discussed the daily context, focused on analysis about the real world actual experiences, and helped construct the relationship between the phenomenology and model aspects (mesoscopic, multi-particle, and supra-molecule) [12]. The context of chemistry teaching should be a socio-scientific issue [16]. There are four contexts about the socio-scientific issues: for stopping the socio-economic growth supported by private importance in a few amount but seriously destroy the environment and endanger the human being; for stopping the causes and consequences of unstable socio-economic growth; for adopting positive laws in politic, education, science and technology; and for associating the first law involving human rights in civic, economy, social, culture, and solidarity [17]. The meaningfulness of sciences in everything emphasizes the social aspect (socio-chemistry) and scientific citizenship [13]. The critical level is faced as science for the transformation in modern society at an eco-reflexive concept [15].

The fourth is about the scientific reading characters that should be iterative, interactive and principled [18]. Iterative is indicated by needed specific skills to understand the content and the purpose of the chemical reading. This character is identified that needs alertness during reading or repeatedly reads to confirm the interpretation made about the reading. Interactive means that served information allowing mental activities as responses to the reading. The responses could be a determination about the info, arranging the interpretation, till making the conclusion. The principled character in chemical reading requires constructing the complete and consistent information. Complete implies the elements of info given in unity data, excluded the wideness and the depth of the explanation. Consistent implies that the information discussed defers to a clear concept or topic.

Reading an academic article, like a chemical reading, makes a metacognitive activity [19-21]. It occurs because there are some mental actions conducted such as elaborating time retention and performance [22], detecting the error towards the preliminary knowledge [23], and sorting the symbols on the passage [24]. When reading, one is pursuing the knowledge on the text by a sophisticated epistemological belief [18]. When one is in this belief mode, one would express some metacognitive
behaviours like selecting a strategy for understanding, applying the preliminary knowledge to solve problems, and checking the progress consistently [25]. Through posing questions after the reading activity could become an indicator to reveal in the metacognitive level related to one’s understanding about the chemistry and the context of the reading [5, 8, 26].

This metacognitive aspect is difficult to observe since the process occurs inside one’s mind [18, 27-29]. Exposing the metacognition could be easier when using a think-aloud protocol [5, 8] that is a technique to verbalize one’s thought [30]. The benefit of this technique is to give the sight of process of memory and actual thinking when one is reading, understanding, strategizing, processing, and deciding [31-33], for revealing the metacognitive strategy [34], metacognitive judgment [35], and metacognitive knowledge [5].

However, the problem is when a chemical article could become the chemical article as the metacognitive stimulant. Moreover, this chemistry teaching and learning in 21st century paradigm should be emphasized to preparing students for a more complex life and work environment involved laboratory activities, technology handling skills, critical thinking and problem solving, integrated learning and interdisciplinary, process oriented evaluation, collaborative work, and communication skills [36-37]. Based on this era demand, the chemical reading should have a specific characteristic for stimulating the chemistry learners to be ready for the workplace. This present study would find the criteria of a metacognitive chemical reading for stimulating a chemical problem posing activity through a think-aloud activity.

2. Method

2.1. Context and Participant

This was a descriptive study of 20 undergraduate students who would be chemistry teacher candidates in third years of Yogyakarta State University, Indonesia. All of them were female from 19 to 21 years old. They were in the international program that used a bilingual class in Indonesia Language and English during their courses. All participants have obtained the basic chemistry course in the first year and the chemical equilibrium course on the second year. They participated voluntarily in these research outside the regular class activities. An ethical consideration was used to protect the data of participants [38-39] that was stamped in an agreement between each participant and the researchers. The participants were encoded by letter A to T.

2.2. Data Collection

Two chemical readings have been designed to stimulating the metacognitive strategy in the reading activity. For the theme of the articles, chemical equilibrium has been selected as a consideration that it was one of the most difficult chemical topic for students [6]. The first reading was an article about the application of chemical equilibrium in human teeth. The second reading was about chemical equilibrium in esterification. The articles were arranged overlapping with other chemistry domains and other disciplines, that fulfilled some criteria about the chemical reading as mentioned before, to stimulate the participants as readers in order to pose problems in question-form at metacognitive level. Table 1 showed the criteria for these chemical readings. The articles have been validated by two experts in related disciplines, and some suggestions from the experts have been used to improve the quality of the reading.

Each participant should pose two problems in question-form after they read each article as the result of thinking and the reflection of the article. The specific directions of the questions were (1) they should be the best complex problems consisting of the initial information and the final state, (2) they should be focused on the application of chemical equilibrium on the article’s context, and (3) they could link another knowledge to pose the question but they should anchor to the chemical equilibrium and its application. The time was limited to 45 minutes to finish their activities.
Table 1. The Differences Between The First and Second Articles

<table>
<thead>
<tr>
<th>Component</th>
<th>Description of Article 1</th>
<th>Description of Article 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Teeth Demineralization and Remineralization</td>
<td>Esterification</td>
</tr>
<tr>
<td>Word count</td>
<td>1095 (from title to last paragraph)</td>
<td>879 (from title to last paragraph)</td>
</tr>
<tr>
<td>Phenomenology</td>
<td>Descriptions/figures of tooth structure and teeth erosion</td>
<td>Descriptions/figures of fruits containing ester</td>
</tr>
<tr>
<td>Model</td>
<td>The comparison of hydroxyapatite and fluorapatite molecule</td>
<td>Newman projection and esterification reaction</td>
</tr>
<tr>
<td>Symbol</td>
<td>Chemical equation of hydroxyapatite equilibria, fluorapatite formation reaction, and the graph about the relationship of temperature and enamel loss.</td>
<td>Chemical equilibrium reaction of esterification and tables of experiment data</td>
</tr>
<tr>
<td>Process</td>
<td>The demineralization and remineralization process</td>
<td>Esterification mechanism</td>
</tr>
<tr>
<td>Techno-science</td>
<td>The function of toothpaste in controlling extremely teeth demineralization</td>
<td>The use of five calculation models in predicting esterification reaction</td>
</tr>
<tr>
<td>Context</td>
<td>A cariogenic life style</td>
<td>The compound that can be having an aroma</td>
</tr>
<tr>
<td>Critics</td>
<td>The correct technique of teeth protection</td>
<td>Application of technology (microwave) for increasing the esterification process</td>
</tr>
</tbody>
</table>

A think-aloud protocol was used in this reading procedure for collecting data about metacognitive activities during reading the article. The first, each participant was given the article and has been simulated by the procedure of think-aloud for recording. Each participant has been requested to vocalize or verbalize their thoughts in front of the recorder during they were reading. There was no pause activity during reading, posing the question till answering the questionnaire. The participants were allowed to drink during the think-aloud activity when necessary. For validating the think-aloud technique as mentioned by [33], the reading activity was conducted one-by-one (not in a group), without researchers interruption, at the comfort place that participant selected before, and on their spare time.

2.3. Credibility

Data recorded about the reading and question posing activities were transcribed by participants’ approval. Audio and paper-based documents were marked by special code to enclose participants’ data. Transcriptions of data were checked by the participants and independent reviewers to inspect time accuracy of each passage segment and the word precision of the think-aloud activity. Coding data of the analysis were verified through a focus group discussion with the related experts.

2.4. Data Analysis

The data collected were transcribed chronologically and validated by the participants. How they read the articles was transcribed and marked in the specific code consisting of the reading pattern and reading parameters. The transcription was arranged embedding and sequentially between the textual word and think-aloud word. Every segment (sentences, equations, and figures/graphs) was measured to the reading rate as think-aloud rate. The rate was converted to reading pattern graph for each reading activity. A normal reading rate was determined as the total words on the text divided by the time consumed. The difference between the think-aloud rate and the normal rate was represented by delta.

A phenomenological reduction method was used to analyze the reading phenomena [39-40]. All data transcribed then were reduced (horizontalization of data). It was carried out by deleting the statements of think-aloud expressions that were not relating to the activities on each parallel segment of reading the article and posing the questions. After this reduction, the data would be encoded and categorized in the same theme that represented the specific expressions and finding towards the metacognitive strategy in the reading activity of the chemical article. The coding from the reading pattern was used to find neomatic themes (what the phenomenon is) and the coding from the think-
aloud activity was used to find neosis themes (how the phenomenon is). Then, a data verification was conducted to clarify and reinforce the themes. The neometric themes were unified as a formulation of the textural definition but the neosis themes were as the structural definition. By blending the textural and structural definitions and adding with data interpretation, the themes were merged to be the essential definition of metacognitive knowledge in chemistry reading activity.

3. Result and Discussion

3.1. Metacognitive Expressions in Chemical Reading Activities

Figure 1 shows the metacognitive expressions of each segment of each article based on eight parameters encoded as the finding in this study. The first expression was repeating the text. This expression indicated that the repeated segment of the text has contributed to the mental activity of readers for more understanding toward the text. The second was marking the text. The marked segment of the text indicated that the content of the specific segment has been appreciated as the important thing. The third was the silent spot. This expression showed that the text was not interesting for the reader, the text was difficult for a think-aloud, or the text was selected as the unimportant part to pass the text. The fourth was the curiosity expression. This expression showed that the content of the text has attracted the readers’ interest to rethink about the phenomenon described. The fifth was the depletion of the reading interest. This expression indicated that the segment of the text has decreased the motivation of the readers to keep reading. The sixth was the reflective expression. This expression was the spot for readers to compare the knowledge they have to the phenomenon described. The seventh was the hesitant expression. This expression indicated that the segment of the text elicited the unbelieved and questionable perception of the readers. The last was the concordant expression toward the text. This expression showed the inquisitive spot but the readers had no capacity to understand the text or the agreement of the readers toward the content of the text but the readers only believed to the text without an analysis. The discussion of the parameters would be described integrated in each theme followed.

Iterations of the inter-sentence in the first article were observed on T to S-1.4 (phenomenology figure), S-1.7 to S-3.1 (terms, chemical equations, numerical data, and process-micro of model representation), S-5.3 to S-6.1 (symbol chemical representative), and S-8.1 to S-9.1 (terms, model chemical representative, and chemical equation). Iterations of inter-sentence in the second article occurred on S-3.1 to S-4.1 (explanation to the dependent chemical representative), S-4.4 to S-5.2 (explanation of the table of symbol and model representatives, the mathematical equation and the chemical equation), and S-9.1 to S-9.5 (explanation of the table of numerical data and mechanical equation). The spots implied that the iterations of inter-sentences were stimulated by the chemical representations.

The repeated spots were obtained on the long sentences, terms’ explanation, numerical data, some representatives and some equations. This re-read activity also contributed to the time consumed by the chemical reading activity. Maximum contributions (≥ 15%: this number was obtained from the ratio of the delta to the normal reading activity) were given by S-1.5 (terms and numerical and chemical data), S-1.8 (terms), S-2.1 (terms), S-3.4 (numerical data), S-8.3 (terms), S-10.1 (terms), and S-9.5 (numerical data and explanation). The data implied that the more data about terms (and their explanation), chemical information, and numerical data on the chemical reading, the more time consumed as the contribution of repeat spots or re-read activities for more understanding towards the text. This case indicated to design the chemical reading activity, the repeat spots that were marked by chemical terms, numerical data and important terms in the text should be determined on time allocation given.

For the article 1 it was observed that the motivation depletion started from S-2.3 (237 words), S-3.4 (318 words), S-6.3 (635 words), S-6.4 (661 words, peak for the motivation depletion), S-7.3 (721 words), S-8.1 (785 words), S-8.4 (859 words), S-10.2 (992 words), and S-10.5 (1046 words). The article 2 was observed from Tb-2.3y (608 words, peak for the motivation depletion) and S-9.5 (855 words). These patterns showed that the motivation depletion reached a high point on 608-661 words.
read. In-depth observation of these motivation depletion spots revealed the factors which affected this depletion. They were passing more than one chemical equation, facing the very long coordinated sentences, facing the sentence containing so many numerical data, symbols, equations, and terms, finding the cardinal number marked to more than one discussion about the topic (e.g. a think-aloud for S-7.2 [First, the weakening of acid potential ...] the word “First” gave the perception on the reader that there were the second, the third, and so on till they did not know), finding the difficult chemical representative for understanding such as a model figure (e.g. S-8.3).

![Figure 1](image_url)

**Figure 1.** Metacognitive expression in chemical reading activities in the first article (a) and the second article (b). Note: The abbreviation T (title), S-X.Y (on paragraph X sentence Y), CE (chemical equation), ME (mathematical equation), Tb (Table), F (figure), ‘ph’ (phenomenology element), ‘sy’ (symbol element), ‘mo’ (model element), and ‘pr’ (process element).

### 3.2. The Structure of The Chemical Reading

According to Figure 1, the different structure between article 1 and article 2 indicated a similar pattern in metacognitive expressions. Although article 1 was longer than article 2, the peak of motivation depletion spots was on the similar range from 600 to 700 words. It indicated that the range was the limitation of interests for the readers to keep reading the chemical articles.
From this study, the reading speed of the chemical readers divided into three categories. The first was the less think-aloud, the second was the formal think-aloud, and the third was the critical think-aloud. The less think aloud was characterized by the speed of reading which was less than 1.7 words per second. The formal think-aloud was characterized by the speed of reading which was between 1.7 and 1.9 words per second. The critical think-aloud was more than 1.9 words per second. These reading speed category was conforming to the type of the scientific reading activity.

There are three types of reading activities [18]. The first was text-based reading that believed all information on the text without consideration of thinking. The second was background-belief-based reading that emphasized on interpretation conforming the initial beliefs. The third was critical-based reading that constructed new idea or revised the belief based on the consideration about the passage. Those types were affecting and fazed by one’s metacognition development [41], because the metacognitive component would play a role if the cognitive strategy was ineffective during understanding the passage [21]. The less think-aloud and the normal think-aloud tended to be the text-based-reader or the background-belief-based-reader. It was dependent on their perception and preparation for question posing in the chemical reading activity. The critical think-aloud tended to be the critical-based-reader since the reader had reflected, compared, analysed, and evaluated the information in the text to the knowledge the reader had.

The complexity of articles reflected the results. The article 1 was less than that of the article 2. It was affected by the intra-discipline and inter-discipline domain of the texts. For article 1, the intra-discipline domains tended to inorganic chemistry (chemical equilibrium, solubility, inorganic complexed compound, mole concept, reaction rate, and buffer solution) yet for article 2 tended to organic chemistry (chemical equilibrium, carboxylic acid derivatives, addition reaction, mole concepts, rate of reaction). Article 1 (about teeth mineralization) was more contextual than article 2 (esterification). For article 1, the inter-discipline domains were dentistry, medical science, biology, and nutrition. For the article 2, the inter-discipline domains were engineering, industry, and education. These multidiscipline application and context in each article has fashioned the article more meaningful for the readers. The chemical reading should be designed inclusively of the legacy of the chemistry [42]. Interdisciplinary should always be appeared in each chemical reading to convey the meaningfulness of the chemistry and the critical-reflective thoughts towards the issues. It required the sufficient chemical literacy and metacognitive chemical reading skill. For preparing the reading should have the sufficient functional and multi-dimensional level of the chemical literacy [43]. The functional scientific literacy was about the ability to define the concept in limited understanding while the multi-dimensional level was about the ability to connect to the intra-discipline of chemistry, inter-discipline, technology, and issues on society [44] called as socio-scientific issue or planetary emergence [17, 45].

3.3. Chemical Representation of The Chemical Reading
This study found a different pattern in the chemical representations used in the articles. Article 1 used uni-representation but article 2 used bi-representation and multi-representation. When this model representation was added by other representation, the different patterns resulted as shown in Table 3.

For the less think-aloud, bi-representation of model and symbol decelerated the reading speed but multi-representation of model, symbol and process accelerated the speed. This pattern implied that for the less think-aloud readers the more complexed chemical representations tended to be more uninteresting spots for reading. For the formal think-aloud, the bi-representation and multi-representation tended to decelerate the reading speed and increase the think-aloud activity. This pattern implied that the formal think-aloud readers were more interested to the more complexed chemical representation rather than the uni-representation. For critical think-aloud, the bi-representation and multi-representation decelerated the higher speed of the uni-representation and accelerated the lower speed of uni-representation. Thus, for chemical reading performances, the dependent representations (bi-representation or multirepresentation) have contributed to the metacognitive activities.
Table 2. The Think-aloud Differences among Uni-Representation, Bi-representation, and Multi-representation

<table>
<thead>
<tr>
<th>Description of Representation</th>
<th>Uni-representation: Symbol</th>
<th>Uni-representation: Model</th>
<th>Bi-representation: Model-symbol</th>
<th>Multi-representation: Model-symbol-process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less think-aloud</td>
<td>[Read-in] (s = 0,5000 w/s)</td>
<td>[Read-of] diagram of the molecular model of the hydroxyapatite and the fluorapatite (silent) (s = 1,0000 w/s)</td>
<td>[Read-of] (s = 0,6667 w/s)</td>
<td>[Read-in and Read-of] (s = 2,1111 w/s)</td>
</tr>
<tr>
<td></td>
<td>[Read-in] in very low pH. The result could be seen that the higher the temperature, the higher the enamel loss (s = 1,6923 w/s)</td>
<td>[Read-in] (s = 1,4286 w/s)</td>
<td>[Read-in and Read-of] (s = 0,9512 w/s)</td>
<td></td>
</tr>
<tr>
<td>Formal think-aloud</td>
<td>[Read-in and Read-of] wow, it is too acidic. The softening is increasing, the erosion is also increasing. (s = 1,4091 w/s)</td>
<td>[Read-of] It is a triangle, uh... (s = 0,5000 w/s)</td>
<td>[Read-of] Eh... ok. (s = 0,5385 w/s)</td>
<td>[Read-in and read-of] (s = 1,2000 w/s)</td>
</tr>
</tbody>
</table>

Note: “Read-in” means that the students read the text in the figure. “Read-of” means that the students read the text of the figure’s caption. “s” symbolizes the reading speed in words/second (w/s).

The reunification of these multirepresentation aspects can train students in metavisual-ability. There are five aspects in metavisual-ability: understanding the convention, capacity to interpret inter-representation levels, capacity to construct a representation, the use of visualization, and problem solving capacity through analogies [46]. All representations can help students construct their mental model. The reunification of these representations is important to convey our students in correct understanding and heuristic comprehension when they effort to learn chemistry. The meaningfulness of chemistry teaching and learning can be reached if the educators can conduct and arrange their readings from observable things (such as: daily phenomena, hot issue in society, or events and trends problems they have ever experienced) to symbolic things (such: give the data, graphics of trends, arranging the equation, and micro aspect of the phenomena) then to sub-microscopic modelling of the phenomena learnt. And the three of representations should be come to the text concurrently. The discrete explanations or separated representations will change our students’ mental model, because students as thinker tend to have a separate form thought [47]. The chemistry teacher should have a good sense to read and interpret their students’ mind framework to assess their stimulation in success or failure.

3.4. Humanistic Approach in Chemical Reading
As shown by Table 1, article 1 and article 2 were designed to contain the four level in humanistic approach of the modified tetrahedral chemistry education [12-15, 48]. The modification was on level 0, the multirepresentation-based. These articles used four representations: phenomenology, symbolic, model and process. The first article was more contextual than the second because in its three levels
from level 1 to level 3, the first article used the more observable things. This reason explained why the pattern in Figure 1 showed the less silent spots in the first article.

The teaching of a sequence of chemistry lessons begins from a relevant socio-scientific context [16]. It means that the teaching progresses from the societal (the familiar), to the chemistry concepts (the unknown), which are needed to better appreciate the issues, or concerns, and then proceeds to the socio-scientific decision making needed (the purposeful learning involving all educational domains). In addition, not only the perspective of chemistry education meaning, but also the development of chemistry education itself contribute in the relevance of chemistry teaching conducting by teachers. Since the end of 20th century, the multirepresentation of chemistry education have become the focus of research in chemistry education that consist of three level representation: macroscopic, symbolic, and sub-microscopic levels [7, 10] plus process level [8-9]. But in the early of 21st century, the three representation was added by human aspect or humanistic approach in chemistry education [48] that emphasized: (1) the rich web of economic, political, environmental, social, historical and philosophical considerations, woven into our understanding of the chemical concepts, reactions, and processes that we teach our students and the general public; and (2) the human learner.

3.5. Chemical Reading Properties
Metacognitive strategy was specific used when reading a scientific reading like chemistry [18]. Before reading one would examine the purpose, measure the text, determine the required and unrequired information, have a prediction about the reading, and arrange the planning [49]. Planning phase began from reading the title and sub-title, scanning the text, activating the preliminary knowledge, arranging the purpose, and expecting the result from the reading [50]. Reading process started by read fast and slow at more informative, interesting, and challenging, re-read, mark, focus on main ideas, clarify explicitly and implicitly about the text, interpret, re-read, monitor the text’s characteristic and the problem on the text, evaluate, and decide [49]. This study showed in Table 2 and Table 3 that the accelerating and decelerating patterns occurred in the chemical representations spots. It implied that these articles have been qualified as the interactive scientific reading.

Figure 1 also showed the repeated patterns in some informational spots of these articles. It pointed out these articles that they have been qualified as the iterative scientific reading. Article 1 was composed by the complete and consistent information of teeth mineralization consisting of ten paragraphs: (1) composition of teeth; (2) teeth demineralization and remineralization reactions; (3) the effect of demineralization; (4) the effect of soda on teeth demineralization; (5) the effect of temperature and cariogenic meals consumption; (6) factors affecting teeth erosion; (7) the technique of weakening the potential acid; (8) upgrading the teeth resistance by fluoride; (9) fluoride-toothpaste; and (10) suggestion for cleaning the teeth. Article 2 was also composed by complete and consistent information of esterification consisting of eight paragraphs: (1) an introduction to esterification; (2) mechanism of the esterification reaction; (3) the example of esterification making; (4) transesterification and saponification; (5) energy on esterification reaction; (6) model mechanism of the esterification reaction; (7) improvement of the esterification product; and (8) determining of the equilibrium constant for the esterification reaction. These declared that these articles were the principled scientific reading. Since these articles had completed all scientific reading characters [18] and all humanistic approach elements [6-10, 12-15, 48], so these articles can be qualified as the metacognitive chemical reading stimulant.

4. Conclusion
A chemical reading should be designed stimulating the higher metacognitive knowledge. From the finding of this present study, some important points should be noticed in arranging the chemical reading. The first is how to offer the chemistry content to be the interesting topic. The contextual topic would increase the motivation and interest of the readers towards their reading activities. The second is how to transfer the chemistry knowledge to the reader. For this case, multiple representations should be required and presented dependently. In another side, the hints of the ideas should be presented in
explained terms by contextual or analogy on the phenomenological representative. The process and model representatives should be presented dependently for the easiness and the comprehensiveness of the knowledge transferred. The third is how to keep the readers on the chemical reading. The chemical reading should be designed inclusively multidisciplinary. The chemical equation, mathematical equation, and others chemical symbolic that could elicit the tediousness, depletion of motivation, and anxiety towards the numerical data should be designed on proper dependent multiple representations. The chemical reading should be maximum on 700 words. The representatives can visualize and save the words to be more efficient.

This present study has designed two chemical articles that have been qualified as the stimulants for chemical problem posing. For educators who want to design their own chemical article should make sure that their articles was contextual and observable in all level of the tetrahedral chemistry education, not more than 700 words, arranged dependently more than one chemical representation, and in its completed information. Time allocation should be considered for determining the reading duration. This study has suggested the additional time about 15% for chemical representation spots (figure, graph, table, and equation). For the students or chemical readers who have the less think aloud style should train themselves in critical-based reader activities to have some metacognitive experiences in their chemical reading performances.

References
[22] Eitel A and Kuhl T 2016 Metacogn. Learn. 11 107-121
[34] Binbarasan-Tüyüzoglu B and Greene J 2015 Metacogn. Learn. 10 77-98

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