

# Implementation of physics mobile learning media to improve student physics perseverance

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**Abstract.** The development of learning media is an alternative way to help students better in understanding the material. For learning chemistry, students not only need knowledge but the way to understand students' cognitive scientifically and their interpretations of thinking about the problem and human life. The research aimed to develop a learning media as a source of learning so that students get more in the learning process. The research method was Research and Development (R&D) by adopting the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), where the product has been developed as a dictionary with the concept of representational triplet in chemistry (macroscopic, sub-microscopic, and symbol). The data collection techniques were test, observation, and questionnaire techniques, while the obtained data were descriptively analysed and N-gain test was calculated to observe student learning progress. The results revealed that understanding chemistry in representation through learning media, i.e. dictionary, can give students an overview of aspects of epistemology and their relationship to their beliefs. That is, validity, practicality, and effectiveness are not only limited to fulfilling the feasibility of a product but how it constructed their preconceptions to be scientific and contextual concepts through the product.

**Keywords:** *the representational triplet in chemistry, learning media, particulate level*

## 1. Introduction

Current technological advancement encourages renewal and utilization efforts of educational technology products. Peter Diamandis, Co-founder of Singularity University in 2012 who published the book "Abundance: The Future is Better Than You Think", said that technology is increasing exponentially as, currently accessing references from all fields which can be done easily through live streaming from social media (Youtube, Whatsapp, Twitter, Path, Instagram, and Facebook), learning with e-learning (Google Classroom, Schoology, Canvas, Edmodo) with uncomplicated mechanisms, short films and music from YouTube, big data storage from Google, homeschooling, scholarship, games, seminars, modules based on augmented reality, virtual lab, online dictionary, free websites, free designing with CANVA, and even local wisdom can be integrated in a variety of teaching materials with the touch of technology. It means that current learning resources are wider and easier such as journals, teaching modules, internet, dictionaries, and encyclopedia. Those things mentioned above are still a small part of the development of the technological world.

Learning resource that can be used is dictionary [1]. The dictionary is a reference book that aims as a source of information for a particular study [2]. Chemical dictionary is a learning resource that contently contains terms in the field of chemistry [3]-[4]. Chemical dictionary that is used in general only contain definitions of terms written in the dictionary, though chemical dictionary can be the main



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learning media on how to interpret and understand terms in learning chemistry [5]-[6]. For example, Na element in the dictionary is simply written; "Natrium/Sodium is a chemical element in the periodic table that has the symbol Na and atomic number 11; it is a soft metal, silvery white, and very reactive". Then, the Na element content which is presented in this way makes the students quite bored because the information obtained is limited [7]-[8]. It means that it takes deeper exploration to interpret each chemical term so that students are able to expand their knowledge about chemistry [9]-[10].

Educational technology is a new way or technique in solving problems especially in the learning context [9]-[11]. Referring to the limitations of the chemical dictionary [12]-[13] in presenting complete content in each term, it indirectly limits the information to students in learning [14]. As a result, their understanding of chemistry tends to be lacking and not deep, so that it requires touch and creativity in presenting terms in the chemical dictionary [1], [15]. Educational technology that is considered to have the potential to change the pattern of learning and to understand chemical materials is by integrating the concept of multiple representation or the representational triplet in teaching and learning chemistry through learning resource such as dictionary [4], [16]-[17]. The used dictionary serves as a learning medium in sharpening the concepts, contents, and meanings of each chemical term in terms of representation (macroscopic, sub-microscopic, symbolic) [4], [18]. Although a variety of applications to support learning by representation can also be found such as software like 4D-Chem, ChemSense, Molecular Workbench, Connected Chemistry.

Another fact is that the search for chemical terms or concepts through the internet and social media has not yet fully convinced of the desired information [19]-[20]. The research shows that the students have difficulty in learning chemistry because they do not have knowledge and skills in a representational manner, so that they need a special approach to make them understand the chemistry not only at the macroscopic level [17], [21]-[22]. This statement leads to the understanding that learning resources in this case the dictionary is one of the strategies or media that can be used by the students in holistically interpreting chemical terms in learning activities [3], [20], [23]-[24]. At the level of macroscopic, learners only see the visible chemical content like experiments in the laboratory and direct observations, so that the learners need to understand chemical materials at the level of particulate matter (submicroscopic), symbolic and mathematical aspects where this concept is called chemical representation or multiple representations [12], [20], [29]-[30].

The multi-representation aspect of learning chemistry has two special functions, namely, the ability to interpret concepts [27] in chemical content and scientifically argued to support the students' understanding in thinking [16], [32]. Then, Johnstone stated that the statement as an approach in learning chemistry was called multiple representation [22], [29]-[30]. Multiple representation has three domain levels (Johnstone's Triangle/Chemistry Triplet) which are introduced, namely macroscopic, sub-microscopic, and symbolic [13], [18]. Microscopic level is the level at which natural phenomena can be observed because it is visible and empiric [22]. Observations and symptoms such as substances deposition, wood and candles burning, changes in starch which is dropped with benedict reagent, temperature, identification of pH in various solution samples, identification of colloidal concepts in the sky such as clouds and sky color, formation of gases and other phenomena [31], and the concept of chemical representation can explain colloidal material to facilitate students' understanding. Laboratory experience is an opportunity for students to strengthen the macroscopic and symbolic levels. Strengthened that at the microscopic level, it includes the particulate aspects as a principle in describing the dynamic movement of electrons such as (atoms, ions, chemical bonds and molecules) and at the symbolic level such as picture form from microscopic and mathematical signs [24], [34].

The development of chemical dictionary learning resource at the level of representation is considered necessary as part of innovation in learning chemistry [26], [34]-[35]. The process of developing this dictionary besides to look for literature reviews, the process also uses ChemSketch software. This software helps in showing the complete molecular structure both symbolic, particulate level, and 2D. Thus, the representation level chemical dictionary (the representational triplet) is a part of the learning media innovation that aims to help students to increase knowledge [22], cognitive [20], [36]-[37], social ability [36], motivation [9], [39], and their literacy [7]. Although the chemical aspects

are mostly adopted in dictionaries such as medical, medicinal such as drugs and biosciences, but the representation level chemical dictionary is more focused on the content of chemical and its effects on learning in the classroom as a medium in increasing the chemical literacy [16], [40]-[41]. As a source of learning, the representation level chemistry dictionary that is developed will present a complete representation of content and information structure; it is easy to understand, complete, and integrated into every aspect of chemistry (organic, inorganic, physical chemistry, basic chemistry, biochemistry, analytical chemistry). This development product which has a continuous potential like this representation level chemical dictionary can be oriented into a digital dictionary as part of technological media updates.

## 2. Research method

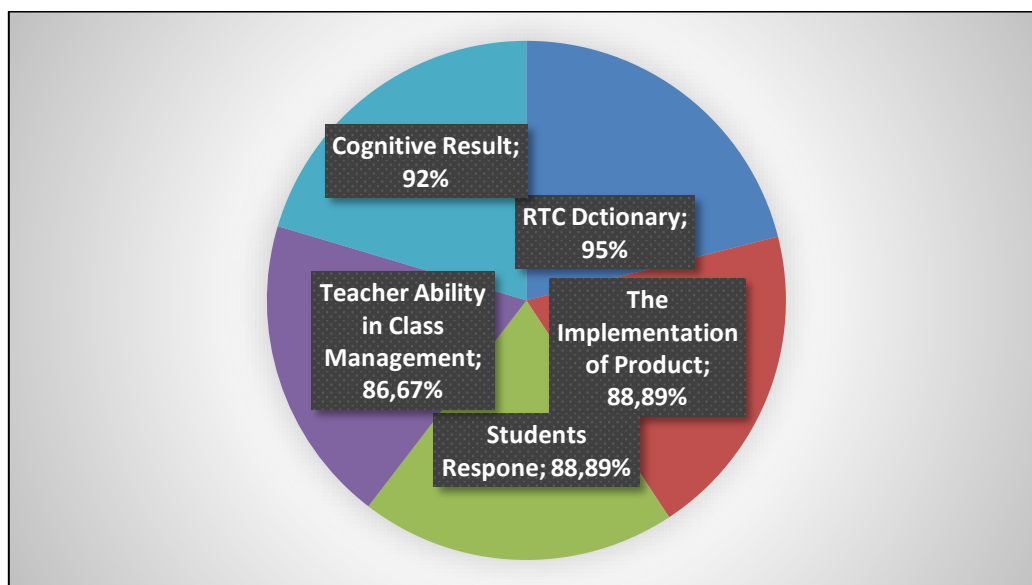
This research was R & D (*Research & Development*) by taking the model of ADDIE as a basic core in developing the research product. The application of the ADDIE model contains 5 stages namely, 1) analysis, 2) design, 3) development, 4) implementation, and 5) evaluation stages. The five stages are the basis of how the product was produced and tested for its feasibility aspects [40]. The sample was the students who have completed several courses which are school chemistry, basic chemistry, organic chemistry, inorganic chemistry, biochemistry, and teaching and learning strategies (SBM) with research location is in University of Lambung Mangkurat, Banjarmasin. The sample was chosen aside from being a chemistry teacher candidate, but on the cognitive level, they are assumed to have understood the chemical content as a whole, it means that their psychology is stated to be matured in interpreting the material. Therefore, if the learning conditions are presented with various problems and analysis in a representation manner, then they have been able to understand or transfer the chemical material in depth [19], [23], [43]-[44]. In addition to understanding, the sample size is also considered to be able to understand the nature of science, so that learning chemistry is not only at the cognitive level but how it is implemented and how it relates to human survival.

Data collection technique was carried out by using test technique pre-test and post-test, and gave a problem based on the concept of representation for the needs of the effectiveness of learning content with the RTC dictionary, and the questionnaire of the feasibility and the implementation test of the product (validity & practicality). The data analysis technique was carried out in stages from the beginning of the development stage until producing product which was then being tested for eligibility. The product is The Representational Triplet in Chemistry (RTC) Dictionary. In the context of research, the feasibility of the product is not only seen from the aspects of the validity, practicality, and effectiveness of the product in a statistical value, but also how the product that was developed contributes and influences the mindset of the sample. The concept of learning that is suited with the concept of the product character will also strengthen the implementation. The undertaken learning adopts the concept of chemical representation and the RTC Dictionary as a form of collaboration to sharpen their understanding on the chemical material [19], [24], [45]-[46].

## 3. Results and Discussion

### 3.1. Product validity and research instruments

Those data summary show the validity of each instrument, including the developed product that is "*The Representational Triplet in Chemistry*" dictionary or dictionary which is called RTC (*ChemSketch* aided application). Overall, the developed product is stated to be valid (valid), both the product and instrument used in the study.

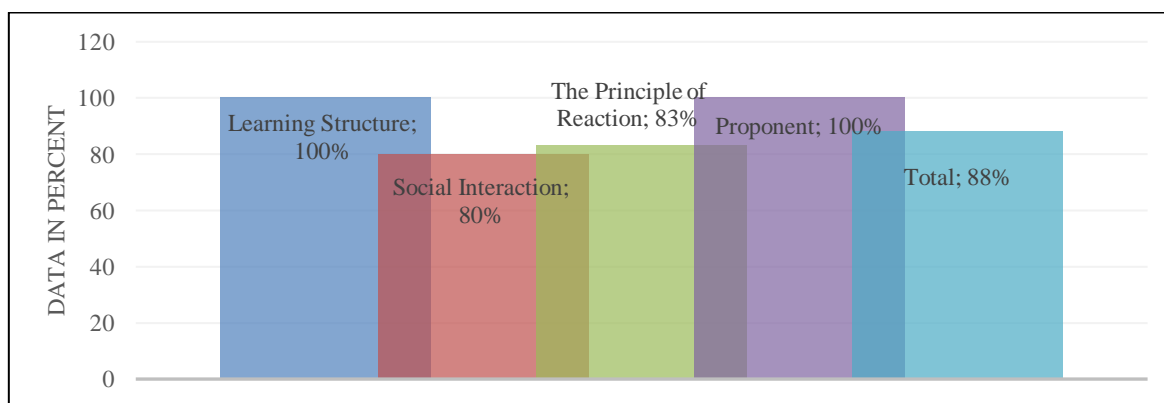


**Figure 1.** Percentage of research instrument validity.

Figure 1 shows that the developed product has met the valid criteria with the information that the instrument is said to be good if it has a reliability coefficient  $\geq 0.75$  or  $\geq 75\%$ , it means that this device can be used with the indicated standard criteria. This validity becomes a reference that the developed product is feasible to be used and implemented in the field, so that this validity is one of the indicators of the feasibility of a product from development result.

### 3.2. Research products practicality

This practicality test was carried out with the aim of knowing the extent to which the RTC Dictionary (*The Representational Triplet in Chemistry*) was able to motivate and change the perspective of the participants in understanding chemistry. In addition, the source of learning must be known its aspects of product practicality in learning chemistry, so that teachers can get reflection material in improving the quality of learning chemistry in the classroom. The following of figure 2 is a picture of the implementation of the development product (RTC Dictionary).



**Figure 2.** Percentage of agreement: implementation of rtc dictionary study resources.

The results of statistical data analysis can be said that the teacher could use the RTC Dictionary (practical context) in the learning process of chemistry to improve the critical thinking skill of the participants, to train the spatial ability, reasoning power, and to strengthen the perspective of the participants in understanding the chemical content or this RTC Dictionary has a scientific impact on

the mindset of the participants. Overall, the RTC Dictionary with the concept of representation is one way to find out the level of understanding of the participants at the particulate level, not only practical in the sense of product appropriateness condition, but also the impact that can be felt by the participants like the participants can interpret deeply the cases offered in the class and the scientific settlement process.

### 3.3. Effectiveness of research products

The initial test carried out was to distribute this RTC dictionary in chemistry learning in Higher Education. The students were the initial target of this trial because they are the foundation of the learning renewal in secondary school as "*prospective teachers*". This trial was conducted in learning chemistry with school chemistry course. The test was conducted with the aim of reviewing the effectiveness of the product and the treatment in the learning process that was attempted to be natural without any editing in the classroom. Learning in the classroom was not glued to that RTC dictionary and how it changes, but it was more focused how RTC dictionary content could improve the way of thinking and improve the cognitive structure of the students in analyzing chemical materials in the representation manner. The learning process carried out by integrating the concept of representation in which the students solve a problem with the concept of representation in order to know the material context is not only at the macroscopic level, but also at the particulate (sub-microscopic) and symbolic levels. If it is considered from the N-gain statistical data, their learning progress is in the medium category, it means that learning in representation at the Higher Education level still needs efforts in forging the students to have reasoning skill and critical thinking.

Table 1 is a recapitulation of the overall N-gain score. The average score of N-gain obtained is 0.5. This 0.5 score indicates that the criterion is "medium", it means that the treatment given is able to give improvement on the specified criteria. Cognitive improvement shows the extent to which the students experienced cognitive changes in their mindset cognitively toward the treatment given in class.

**Table 1.** N-gain point.

No		Average	Average of N-Gain
1	Pre-Test	58.38	0.5
2	Post-Test	82.81	

In connection with this explanation, the proof of the medium category (N-gain = 0.5) is supported by the visualization of figure 1 and 2. Even though the N-gain score is 0.5 with the criteria of "medium", the value indicates that the treatment given made the participants had experienced changes especially in cognitive aspect. Misconceptions often occur because they do not have the ability at the particulate level, so that they have difficulty in interpreting in macro and symbol levels [47], [48]. Learning chemistry can only be interpreted correctly and scientifically if students are able to connect a concept at the level of representation (macroscopic, sub-microscopic, and symbolic) [47]. If combined with the results of the conducted research that learners have not been fully or just having enough competency in representation, then it needs deeper strategy to forge their cognitive abilities at the level of representation. The intended strategy is to increase the practice of both theoretical and experimental analysis, so that the concept of representation can be internalized by them [48]–[50]. If other research using the concept of *hands-on activity* to sharpen the ability of the particulate level, then the RTC dictionary had used problem analysis approach based on particulate level representation to sharpen the previous scientific understanding that they have already owned. It is like the questions and/or cases discussed below that they analyze compounds to the level of chemical structure, orbital energy, electronegativity, chemical bonding processes, and other scientific aspects. As a result, their critical thinking skills and analytical skills will gradually be trained, so that it strengthen their understanding in learning.

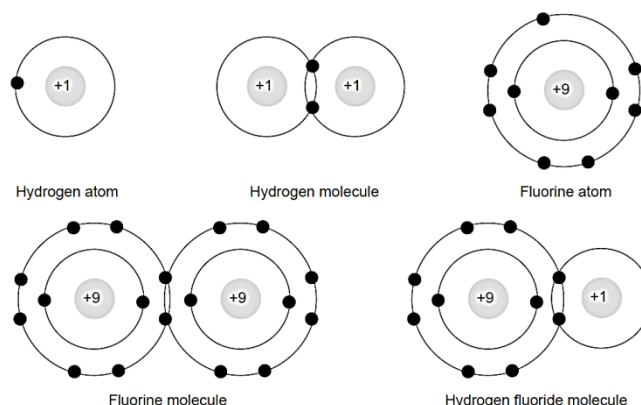
**Case #1 Why hydrogen can react with fluorine to be hydrogen fluoride?****Figure 3.** Case #1 about the reaction of the element H with F [51].

Table 2 is the mindset or cognitive structure of the students in response to case #1, which is why hydrogen reacts with fluorine based on Figure 3. Cases given to the students are material taken from a book entitled “Chemical Misconceptions: Prevention, Diagnosis and Cure Vol. 2: Classroom Resources” [51]. This material is very relevant to the developed RTC dictionary content, which in this dictionary it adopts the concept of representation (macroscopic, submicroscopic, and symbolic), so the students can practice their particulate level ability in understanding chemical material. In other words, the RTC dictionary as a representation-based learning resource and a case that is presented as a form of teacher assessment of students’ understanding of the extent to which the impact of the product being developed have contribution to chemistry learning. Figure 4 shows that the ability of the samples at the particulate level is quite good because they are classified as having an understanding of the reaction between hydrogen and fluorine with scientific reasons. There are four reasons stated in this discussion, where the reason number one to four are reasons that represent the students’ answers on the case 1 given. The following explanation of reasons 1-4 by the students based on case 1.

**Table 2.** Student responses are written based on case 1 given.

Students’ first response for case 1
<i>The first Response is that the reaction of <math>H_2</math> element with <math>F_2</math> element occurs because it is related to stability. That is, the concept of octets is in this case where in the concept of chemistry the stability becomes one of the reasons why every chemical element can react. The Hydrogen element has electron configuration of 1 (<math>H = 1</math>), while Florin has electron configuration of 9 (<math>F = 2.7</math>). If F Element wants to achieve stability, then element F must react with H element where H has 1 electrovalence and F element has 7 electrovalence, it means that the F element requires 1 electron to be stable so the reason of number 1 is considered relevant in addressing the case #1 and this reason is scientific and is a very basic reason as a foundation for knowing the chemical reaction.</i>
Students’ second response for case 1
<i>The second reason is that "This reaction occurs because fluorine atom has very high electronegativity, so it has a potential to bind hydrogen". This second reason adopts the concept of electronegativity, where electronegativity is a condition in which a chemical element has a tendency to attract other elements that have small electronegativity or which are more electropositive. Referring to that concept if the F element has a very large electronegativity (Pauling scale = 3.98) compared to the H element (Pauling scale = 2.20), causing the Flor element to form a reaction to hydrogen. This reason is considered to be very scientific, considering the concept of electronegativity is also the reason why fluoride acid in acidic base is a weak acid. Another reason is that because of the high electronegativity of flor, so that at the level of particulate, the hydrogen element is as immersed in the F atom, where the attraction of the F atom is very large towards H.</i>

**Students' third response for case 1**

*The third reason, some samples also assumed that the reaction occurred between H and F is because they have the same nature which is "non-metal". Non-metal is a group of chemical elements that is electronegative, that is easier to attract valence electron from other atoms rather than releasing it. It means that F is a group of those mentioned. Covalent bond that occurs between non-metals and non-metals is the concept of sharing electrons such as  $H_2$ ,  $F_2$ ,  $Cl_2$ , and or covalent bond can also occur between different elements such as methane, ethylene, and acetylene. Scientifically, this 3rd reason can also be used as another assumption in analyzing the case #1, although additional review is needed with other concepts.*

**Students' fourth response for case 1**

*The fourth reason is "There is a tendency of the orbital nature of each element so that it causes a reaction", where this reason is also actually related to the previous reason. The concept of stability is also related to how the orbital condition of each element, it means that the condition of the orbital determines the stability of an element or chemical compound. The following is an illustration of the orbital condition of H and F element.*

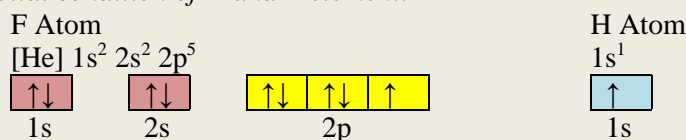
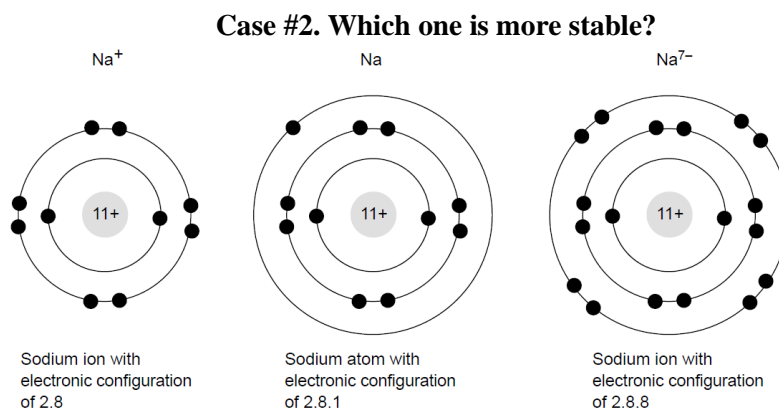


Table 2 shows the various reasons of the students in writing their analysis for case 1, where each student gave a reason of "why does hydrogen react with fluorine?" The reasons shown in table 2 are assessed as a form of students' interpretation of the case and how far the students' understanding or cognitive at the particulate level. The reasons of the students in table 2 show that their cognitive structure is still weak, even though they should already have a strong and scientific understanding in interpreting case 1. It means that the reasons shown in table 2 can be a reference material for teacher to find out how far the students' understanding in representation. Although there are sufficient scientific reasons from the students, as some students have understood about the "electronegativity concept", but there are also errors such as the term "fluoride acid" where this term should be "hydrofluoric acid" and most students assumed that explaining HF is only by using the concept of octet rules whereas there are many things must be explained related to this case including thermodynamic factors. In other words, explaining case 1 requires a lot of explanation in chemistry.

Overall, the cognitive structure of the samples (students) regarding their perspectives about science is at the level of thinking in terms of representation (particulate level). This cognitive structure is much needed in understanding chemistry both in content and or in the context of chemical science. Understanding in terms of representation in chemistry can change their thinking in achieving competence, it means that chemistry does not mean only understanding the macroscopic concepts without an in-depth review of the reasons for each compound formed structurally and in a periodic nature of the elements, but also how they are understood at the particulate level [24], [26], [53]-[54]. This strategy is always growing their critical thinking patterns, also able to practice their spatial ability in recognizing the shape and nature of a chemical molecule.



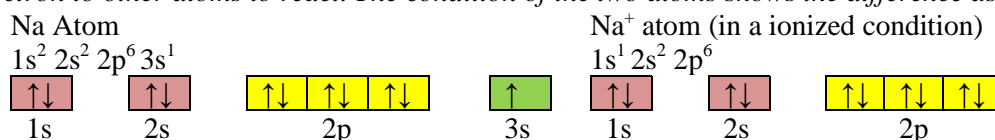


**Figure 4.** Analysis of the sodium element for case #2 [51].

Case #2 is to identify the stability of sodium (natrium) element with various conditions so that this case is very useful for the teacher in analyzing the extent to which the students have multi-representation ability in understanding the chemical content. The case #2 they averagely have a response to the statement given which is as follows.

Na<sup>+</sup> is more stable than Na:

**Students' responses:** because Na atom has 1 valence electron ( $\text{Na} = 2.8.1$ ), while  $\text{Na}^+$  ion has 8 valence electrons ( $\text{Na}^+ = 2.8$ ), where the  $\text{Na}^+$  condition is releasing 1 electron to form an electron configuration which is similar to the noble gas element (neon = 2.8), while the Na condition has 1 electron that must be released if seeing the concept of stability. It means that the 1 electron makes Na needs treatment to be stable such as reacting with atoms or other compounds. Besides the electron configuration, the difference between  $\text{Na}^+$  and Na is the number of shells in each atomic condition. In essence, the condition of  $\text{Na}^+$  is more stable because in subshells all the orbitals are fully filled so that the position of  $\text{Na}^+$  has been in an octet state (stable), while Na requires additional energy to release 1 electron to other atoms to react. The condition of the two atoms shows the difference as described.



The participants' responses to the case #2 were considered to be developing and quite scientific, it means that in terms of the stability and reasons for orbital factors that made the participants' reasons are considered to have reached the particulate level.  $\text{Na}^+$  and Na orbitals above clearly indicate that the Na condition is less stable than  $\text{Na}^+$  where the Na atom has a  $3s^1$  subshell which contains 1 electron. The electron has the potential to react with other orbitals at certain energy, although it looks half full but overall that the  $1s^2 2s^2 2p^6$  subshell in Na has reached stability so that the electron in the 3s subshell must be released. Another reason is that the  $1s^2 2s^2 2p^6$  subshell will most likely not experience excitation or transfer of an electron to certain energy level on certain atom. Then, due to the factor of  $3s^1$  subshell that makes the condition of Na unstable, it needs to release electron in that subshell to achieve stability. It is different from the  $\text{Na}^+$  that the atomic orbital of  $\text{Na}^+$  is fully charged or in octet state (stable), it is likely that  $\text{Na}^+$  ion will not experience a release of electrons.



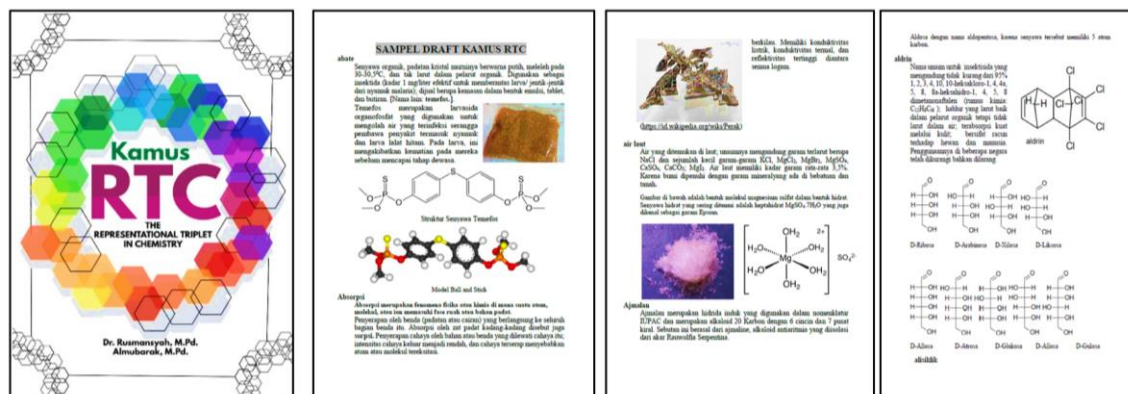


Figure 5. The visualization of product.

Figure 5 is a visualization of the RTC dictionary that has been developed, where students can study chemistry based on the concept of representation. Researchers emphasize that the main orientation is not on the product produced but how the product can influence and contribute to students' mindset so that they can understand chemistry in depth and scientifically. Overall, the RTC Dictionary with the help of the *ChemSketch* application contributed to the participants' mindset in representation manner. In addition to cognitive learning outcomes of students who have experienced progress, the problem solving skills of the discussed cases could be assessed that the participants have understood chemistry in depth. The RTC dictionary which of course with the concept of chemical learning by representation is an alternative way in which the teachers/instructors are able to reduce level of misconceptions that have been happening both in the school environment and in higher education [19], [24], [43], [52], [55]–[57]. In other words, the development of a creative and innovative product in the context of chemical learning is the main point that must be done by the teachers, remembering that the paradigm of the chemical material which is abstract, difficult, and has a high level of complexity always has sustainability to the participants. It means that actions such as the use of media or learning resources that support the participants' learning way are needed, and the representation chemical concept must be adopted, so that the percentage of misconceptions can be minimized [3], [46], [51].

#### 4. Conclusion

The development of learning media in The Representational Triplet in Chemistry Dictionary and its integration in learning is a form of strengthening the quality of chemical learning. The RTC Dictionary is an educational technology product that is considered capable of being a solution in solving problems in interpreting deeper chemical material. In other words, the development of innovative product (RTC Dictionary) gives a different perspective to prospective teachers in translating the chemical material in understanding chemistry, it means that learning chemistry with the concept of representation will stimulate the students' thinking that chemical matter is not only to be known, but also how this interpretation constructs their preconception becomes a scientific concept. Renewal in the context of learning is an obligation to do by the teachers, remembering that the exponentially fast-moving technological world, so it will produce superior, creative, innovative and competitive human beings.

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