Analysis of Undergraduate Mathematic Students’ Understanding on Microscopic Representation of General Chemistry Lecture based on their Scientific Reasoning Ability

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Abstract. Undergraduate mathematic students (UMS)’ scientific reasoning can affect their ability to do abstraction of microscopic phenomenon. Based on Piaget’s theory of cognitive development of UMS are in operational formal category, but this research was found that only 2 students of UMS whose have scientific reasoning as formal category. The aim of this research was analysing UMS’ achievement on understanding microscopic representation based on their scientific reasoning (concrete, transition, or formal category). Mixed method was used in this research which integrated quantitative data (test score) and qualitative data (analysing of understanding and scientific reasoning ability). The research funding that mean score test of UMS as formal reasoned (F) were the highest. UMS as transition reasoner and concrete reasoner were difficult to solve stoichiometry calculation which contains microscopic representation. Question about limiting reactant based on molecule representation, that 10,7% of UMS as concrete reasoner (C) answered there was no limiting reactant. The characteristic of concrete reasoner (C) is understanding based on observable object. They difficult to transform it as microscopic representation (number of molecules as reactant and product) which was written on net reaction as symbolic representation. They did not consider stoichiometric chemical equation by using representation of X as a variable in mathematical calculations. Another response that 14,3% of UMS as transition reasoner (T) determined limiting reactant by using logical mathematic equation of (mole=mass/molar mass) without considered coefficient in net reaction. In general chemistry learning, requires innovation to visualize microscopic aspects, so that UMS at concrete reasoning and transitions reasoning have the ability to interpret microscopic phenomena which is not observed by naked eyes.

1. Introduction

General chemistry is one of the compulsory lectures which is programmed by first year students on faculty of mathematics and natural science Universitas Negeri Surabaya. UMS have nice algorithmic understanding on balancing chemistry equation, fundamental chemistry law, stoichiometry, and pH calculations. The problem was raised when their algorithmic understanding which connected to chemistry representations.

The chemistry concepts are constructed by three representations namely macroscopic, microscopic, and symbolic. Microscopic representation requires abstraction process on particulate phenomenon [1]. Chemical bounding and intermolecular force as example of general chemistry matter which must truly understood, so UMS can predict ionic compounds have higher boiling point than covalent compounds. It is used for analysing about HF and H₂O as polar molecules, but has different boiling point. \( T_b H_2O = 100^\circ C \) is far higher than \( T_b HF = 19.5^\circ C \), because number of hydrogen bonding differ between H₂O and HF.
Understanding on microscopic representation is affected by students’ cognitive development. Piaget stated that students’ age over 12 years is classified on formal operational level who can construct abstract concept individually [2]. They can interpret phenomenon about how two atoms bonds each other by sharing electron or transferring electron to form compound. They can do abstraction about the effect bond strength on boiling point, although they are not given scaffolding such as 2D and 3D visualization. Ballester Perez, et. al identified misconceptions on 13% first year students stated that NaCl solid could conduct electricity because has nonpaired; 13% senior high school students stated that hydrogen bonding was stronger when compound which has more number of hydrogen atoms; and 16% undergraduates and 19% senior high school students had perception that compounds which had hydrogen bonding when consist of H atom with F, O, N atoms, example CH$_3$F [3]. Khoirina, et. al found 6.8% of 88 senior high school students which have formal level.

Those findings proof that undergraduate students have not formal category on scientific reasoning, however their age classified by Piaget as formal operational category [4]. The lower scientific reasoning can trigger them to reach understanding on microscopic representations which is not accepted scientifically. Lawson described that students’ scientific reasoning can evaluated by valid and reliable instrument Lawson Classroom Test of Scientific Reasoning (LCTSR)[5]. Lawson classified scientific reasoning on three categories are concrete, transition, and formal. UMS’s ages are classified by Piaget as formal operational which theoretically can interpret microscopic phenomenon, must be analysed based on their scientific reasoning ability.

2. Method
Analysis of UMS’s understanding on microscopic representation was carried out on 28 of 31 students of mathematics education study program on the odd semester in the academic year 2019/2020 Universitas Negeri Surabaya. Mixed method was used in this research, quantitative aspect in comparing UMS’ understanding based on mean score and calculating number of UMS whose have formal, transitional and concrete. Qualitative aspect in making code and analysis of their understanding based on their scientific reasoning ability. Their answering the middle test and final test describe their understanding on microscopic representations. The findings of UMS’s understanding which were not accepted scientifically would be analysed based on their scientific reasoning ability.

| Total Scores of LCTSR | Category of Scientific Reasoning Ability |
|-----------------------|------------------------------------------|
| 0-4                   | concrete                                 |
| 5-8                   | transitional                              |
| 9-12                  | formal                                   |

Based on LCTSR instrument, Lawson classified three categories of reasoning ability that are concrete, transitional, and formal. The difference is found in the student's ability to do concept abstraction on microscopic aspects. Students as formal reasoner can imagine particulate figure individually and do abstraction microscopic phenomenon. Students as transitional reasoner have reasoning process on transition to formal, its means that they cannot fully construct imagination on microscopic phenomenon. Students as concrete reasoner do not have ability to understand particulate or microscopic phenomenon as non-observable object.
3. Data Analysis
The number of UMS who have scientific reasoning category as concrete (C), transitional (T), and formal (F) are represented on the following diagram:

![Diagram showing the number of UMS scientific reasoning categories]

**Figure 1.** Number of UMS’ scientific reasoning category as concrete (C), transitional (T), and formal (F)

The majority of UMS are still in concrete and transitional reasoning, respectively 11 students and 15 students. Whereas just 2 students of UMS who have formal reasoning. UMS’ scores on middle test (UTS) and final test (UAS) were evaluated to describe the understanding differences on general chemistry lecture:

![Bar chart showing understanding scores of UMS as Concrete Reasoner (C)]

**Figure 2.** Understanding scores of UMS as Concrete Reasoner (C)

![Bar chart showing understanding scores of UMS as Transitional Reasoner (T)]

**Figure 3.** Understanding scores of UMS as Transitional Reasoner (T)
Based on those diagrams, UMS as concrete reasoner (C) have UTS mean score 62.8 and UAS mean score 75.9. UMS as transitional reasoner (T) have UTS mean score 73.5 and UAS mean score 81.2. UMS as formal reasoner (F) have UTS mean score 79.1 and UAS mean score 90. Mean scores of UMS as formal reasoner (F) were higher than UMS as transitional reasoner (T) and UMS as concrete reasoner (C). The differences of understanding score of them indicated that scientific reasoning ability can affect their understanding on microscopic representation.

4. Result and Discussion
Percentage of UMS as concrete reasoner (C) and UMS as transitional reasoner (T) are greater than UMS as formal reasoner (F). It is contrast to Piaget's theory of cognitive development which describes that students over the age 12 years are included in formal operational stage who have ability to do concepts abstraction [8]. However, the funding in this research that only two students who have scientific reasoning on formal category (F). Microscopic representation as phenomenon which cannot observed, so made UMS as concrete reasoner (C) and UMS as transitional reasoner (T) were difficult to abstract particulate phenomenon.

Concrete reasoner can solve the problem which is oriented on observable object [9] so they cannot independently construct phenomenon at the particle level. The findings on this research that many concepts is not understood correctly by UMS as concrete reasoner (C) and UMS as transitional reasoner (T) which are higher percentage than UMS as formal reasoner (F). Their understanding on microscopic representation is not accepted scientifically which is listed on table 2 bellow:

| Understanding | UMS Percentage |
|--------------|----------------|
| %C | %T | %F |
| Q2. Physical Change | | |
| a. Change in shape or size | 3.6 | 3.6 |
| b. Change of state (solid to liquid) | 3.6 | 3.6 |
| c. Involve physical condition without chemical reaction | 3.6 |
| d. Does not require ion | 3.6 |
| e. Reversible change | 3.6 |
| f. Can observed | 3.6 |
| g. Produce new substance | 3.6 |
| h. Example phenomenon such as rusting of iron, burning candle, and soaked potatoes in salt water | 7.1 |
| Q2. Chemical Change | | |
Understandings are not correct scientifically

| Scientific Understanding | UMS Percentage |
|--------------------------|----------------|
| a. Change of state, example melted ice | 3.6 |
| b. Require ion | 3.6 |
| c. Irreversible change | 3.6 |
| d. Can not produce new substance | 3.6 |
| e. Can not observed | 3.6 |
| f. Change to produce chemical substance, example sugar dissolving in water | 3.6 |

Q5. Determine limiting reactant based on number of mole
Do not solve through stoichiometric calculation

| Reactant Number | Percentage |
|-----------------|------------|
| before reaction | 14.3       |
| after reaction  | 10.7       |

Q6. Determine limiting reactant based on particulate representation before and after reaction

| Reactant Number | Percentage |
|-----------------|------------|
| before reaction | 25         |
| after reaction  | 14.3       |
| overall reaction| 3.6        |

Q9. Chemical Bonding

| Bonding Type | Percentage |
|--------------|------------|
| a. Ca and Cl form CaCl₂ through covalent bonding | 7.1 |
| b. Lewis structure of CaCl₂ is represented by sharing electron | 3.6 42.9 |
| c. CaCl₂ is produced by polar/nonpolar covalent bonding and NH₃ as nonpolar covalent compound | 3.6 7.1 |
| d. NH₃ is produced by ionic bonding between anion N³⁻ and cation H⁺ | 3.6 |
| e. CH₄ is produced by ionic bonding | 3.6 |
| f. CH₄ is produced by polar covalent bonding | 3.6 |
| g. Ca and Cl form CaCl₃ through coordinate covalent bonding | 3.6 |
| h. Molecular formula such as CaCl, CaᵥClᵥ, NH, NH₂, CH, dan CH₂ | 14.3 14.3 |
| Understandings are not correct scientifically | UMS Percentage |
|-----------------------------------------------|----------------|
| i. Boiling point of CH$_4$ is higher than NH$_3$ | 7.1 %C 7.1 %T |
| j. Boiling point of NH$_3$ is higher than CaCl$_2$ | 3.6 %C 7.1 %T |

**Q12. Magnetism Properties**

| a. The electron configuration does not obey stability of full/half full orbital | 14.3 %C 32.1 %T 7.1 %F |
| b. Magnetism of Cr is equal to Al | 3.6 %C 7.1 %T |
| c. Higher magnetism is influenced by smaller total spin value | 7.1 %C 3.6 %T |
| d. Magnetism is influenced by electronegativity as periodic properties | 3.6 %C 7.1 %T |

**Final Test (UAS)**

| Q3. pH Calculation of acid and base mixture | 7.1 %C 3.6 %T |

**Q4. Colloidal Properties**

| a. Optic properties of Colloid Solution can be passed by light without scattering process | 3.6 %C 7.1 %T |
| b. Colloidal properties are observable by microscope ultra | 3.6 %C 7.1 %T |
| c. Colloidal particles can be observed by naked eyes and its particles move freely | 3.6 %C 7.1 %T |
| d. Colloidal particles just move freely in liquid medium | 3.6 %C 7.1 %T |
| e. Colloid can be observed by naked eyes on dispersed phase and dispersion medium | 3.6 %C 7.1 %T |
| f. Colloid can move freely because it is formed by dispersed phase and dispersion medium on same state as gas | 3.6 %C 7.1 %T |

### 4.1 Q2. Physical Change

Percentage of UMS as concrete reasoner (C) are higher than others. Its found that they did not reach true understanding on microscopic aspect. Characteristic of concrete reasoner (C) is understanding concept which is observed by naked eyes. This is supported by Jufri, et al. (2016) research that prospective student teacher have low reasoning abilities so classified on concrete level. UMS as concrete reasoner (C) understood physical change as change in shape and observable, example wood becomes desk or water becomes ice cube. They did not reach truly understanding on macroscopic phenomenon that physical change is not produce new substance, example melted ice in before and after as same molecule H$_2$O.

UMS as transitional reasoner (F) gave physical change phenomenon as burning candle. It is proof that UMS as transitional reasoner (F) who have reasoning process transition to formal through hypothetic thinking[10]. Burning candle is not fully true as example of physical change, because its...
phenomenon can be used as an example of a chemical change. If we focus on melting a candle, before and after it is paraffin wax, so it can be classified as a physical change because it does not produce a new substance. But if we focus on the burning process of candle wick, before it is white wick when it burns it becomes black, indicating the production of carbon (arang), CO₂ gas, and H₂O gas, so it can be classified as a chemical change because it produces a new substance.

4.2 Q2. Chemical Change

UMS as a concrete reasoner (C) understands that microscopic representation is not accepted scientifically, because reasoners at the concrete level do not have the ability to interpret unobservable phenomena [9]. They understand that a chemical change is an irreversible process. This definition is based on the observation that rotten bread cannot return to its original state. This is in line with the findings of Kind and Horton that students understand a chemical change as an irreversible change on its original state [11][12].

Different results were shown by UMS as a transitional reasoner (T) that they understand correctly the concept of chemical changes as producing new substances. However, 3.6% of students gave incorrect examples of a chemical change as dissolving sugar in water. In their minds, they imagine that the process of dissolving sugar can produce new substances, but this is not accepted scientifically. True process of dissolving sugar in water is represented in the figure below:

![Interactions between Sugar and Water Molecules](slideplayer.com)

Before as solid sugar with bulky sucrose molecules and after as distributed sucrose molecules in water. Intermolecular interaction between dipole H₂O and sucrose molecule breaks the attractive force of sucrose molecules, so they are evenly distributed in water. Intermolecular interaction does not break C, H, O bonds in sucrose molecules. Dissolving sugar in water does not produce new substances, so it is not true as an example of a chemical change.

Dissolving NaCl in water is an example of a chemical change. Before as solid NaCl consists of cation Na⁺ and anion Cl⁻ through electrostatic force in face centered cubic type of crystal structure. Intermolecular force between dipole H₂O and ion Na⁺ or Cl⁻ namely ion-dipol interaction. It is strong enough to break electrostatic force between Na⁺ and Cl⁻ as ionic bonding, so ion Na⁺ is attracted by the negative pole of H₂O molecules and ion Cl⁻ is attracted by the positive pole of H₂O. Dissolving NaCl in water produces new substances, namely hydrated Na⁺ ion and hydrated Cl⁻ ion which is represented in the following figure:
4.3 Q5. Determine limiting reactant based on number of mols

Determine limiting reactant in two version to test understanding on algorithmic knowledge and understanding on conceptual knowledge. Holme and Murphy stated that understanding on algorithmic knowledge and understanding on conceptual knowledge involve dual processing model cognition (heuristic and analysis) [13]. Algorithmic knowledge tends to a heuristic process that apply familiar mathematic equations which does not involve more cognitive process, so students are fast to solve calculation problems in chemistry subject. Meanwhile, conceptual knowledge tends to an analytical process that require students’ cognitive process especially in microscopic representation and takes a long time to solve problem.

The findings in this research are 75% of UMS succeeded in solving the problem involves stoichiometric calculation as determining the limiting reactant based on number of moles substance. After analysed the UMS’ answers, there were two kinds of calculation process, namely through manner (i) the stoichiometric calculation and manner (ii) calculation through the (mole/coefficient) value of the reactants. The majority of UMS solved chemistry calculation through same process which is taught in chemistry class, represented in manner (i) on table 3. However, there are two UMS as concrete reasoner (C) and one UMS as transitional reasoner (T) solved chemistry calculation through other process as manner (ii) on table 3. The following figure represented manner which were used by them:

Table 3. UMS’ Algorithmic Knowledge on Determining Limiting reactant through Numerical Data

| Manner (i) | Manner (ii) |
|------------|-------------|
| (5) Fe + 3O \rightarrow Fe_3O_4 | Fe + \frac{\frac{3}{2}}{3} = Fe_3O_4 |
| \[ \begin{align*} \text{M} & = 5.64 \text{ g} \\ \text{Fe} & = 55 \times \text{g} \\ \text{O} & = 3 \times 16 \times \text{g} \end{align*} \] | \[ \begin{align*} \text{n Fe} & = \frac{55 \times 5.64}{55} = 5.64 \\ \text{n O} & = \frac{3 \times 16 \times 5.64}{55} = 8.04 \end{align*} \] |
| \[ \begin{align*} \text{Calculate Fe} & = \frac{55 \times 5.64}{55} = 5.64 \\ \text{Calculate O} & = \frac{3 \times 16 \times 5.64}{55} = 8.04 \end{align*} \] | \[ \begin{align*} \text{n Fe} & = \frac{55 \times 5.64}{55} = 5.64 \\ \text{n O} & = \frac{3 \times 16 \times 5.64}{55} = 8.04 \end{align*} \] |
| \[ \begin{align*} \text{Calculate Fe} & = \frac{55 \times 5.64}{55} = 5.64 \\ \text{Calculate O} & = \frac{3 \times 16 \times 5.64}{55} = 8.04 \end{align*} \] | \[ \begin{align*} \text{n Fe} & = \frac{55 \times 5.64}{55} = 5.64 \\ \text{n O} & = \frac{3 \times 16 \times 5.64}{55} = 8.04 \end{align*} \] |

4.3 Q5. Determine limiting reactant based on number of mols
The other process to solve calculation problem on manner (ii), proofs that UMS’ algorithmic knowledge classified on good mastery. They generalized that the limiting reactant has the smaller value of (mole/ coefficient), it supports the definition of limiting reactant which totally consumed in chemical reaction. Although they did not use the stoichiometric calculation on manner (i), they solved limiting reactant through manner (ii) is accepted scientifically. The majority of UMS can solve well chemistry calculation based on numerical data.

4.4 Q6. Determine limiting reactant based on particulate representation before and after reaction

Determine of limiting reactant based on microscopic representations to test UMS algorithmic knowledge based on non-numeric data. It is important to analyze if their algorithmic knowledge combines with understanding on microscopic representation that requires UMS’ability to transform aspect as molecules before and after reaction became numeric data as number of molecules in chemical equation as symbolic aspect. Question bellow was used to test their understanding on algorithmic knowledge and microscopic representation:

*Look at this figure shows initial condition of chemical reaction between NO gas and O2 gas and its final condition of reaction:*

![Figure 7](image)

*Figure 7. Write chemical equation (balance) and determine limiting reactant! [14]*

The majority of UMS could not complete to determine the limiting reactant based on the particle representation on before and after reaction. There are 25% UMS as concrete reasoner (C) and 14.3% UMS as transitional reasoner (T) transformed the microscopic representation in chemical equation as the overall reaction without net reaction. Meanwhile, just one UMS as formal reasoner (F) who had correctly solved problem to determine limiting reactant using microscopic aspect. Their answer can represented on table 4:

| UMS’ Scientific Reasoning Ability | Answer to determine limiting reactant |
|-----------------------------------|---------------------------------------|
| UMS as concrete reasoner (C)     |                                       |
|                                   |                                       |
| UMS as transitional reasoner (T) |                                       |
|                                   |                                       |
| UMS as formal reasoner (F)       |                                       |

Table 4.

UMS’ Algorithmic Knowledge on Determining Limiting Reactant through Microscopic Representation

UMS as concrete reasoner (C) had difficulty transformed the particle representation in the chemical equation. They misinterpreted the limiting reactant based on observable particle in figure at before
reaction there are 6 particles of O2 gas became 3 particles of O2 gas at after reaction. This contradicts the scientifically concept of limiting reactant which has completely reacted and means that it is not found at the end reaction [14]. UMS as concrete reasoner (C) understood that O2 gas as the limiting reactant was not accepted scientifically. The failure to transform the microscopic aspects into the symbolic aspects is caused by their lower ability to interpret particulate phenomena independently [1] by them who are still at a concrete level of reasoning [9]. This is supported by the research of Barak and Dori that students need to present material with a concrete model to make it easier for them to understand the unobserved microscopic aspects[15].

Students are classified as formal reasoning who have ability to abstract non-observable phenomenon [10] and ability to transform particle representation as microscopic aspect into chemical equations as symbolic aspect[16]. UMS as formal reasoner (F) wrote chemical equation as overall reaction and net reaction, so they were easier to identify limiting reactant as NO gas through presence of reactant species at the end reaction. Based on microscopic representation and overall reaction, NO gas as limiting reactant because there are not NO gas particles at the end reaction or after reaction.

4.5 Q9. Chemical Bonding

Chemical bonding requires UMS understanding on microscopic representation especially electrons arrangement in the Lewis structure by sharing electron or transferring electron. This microscopic phenomenon was partially understood by UMS as transitional reasoner (T). The findings that 42.9% UMS as transitional reasoner (T) wrote Lewis structure of CaCl2 by sharing electrons and classified as ionic bond, which can be seen in the following figure:

![Lewis structure of CaCl2](image)

Figure 8. UMS as transitional reasoner (T) understood on chemical bonding

The incorrect prediction the boiling point of ionic compounds was caused by the UMS as transitional reasoner (T) had inability to transform Lewis structure according to the type of chemical bonding. Students with transitional reasoning actually have ability to construct imagination at particulate level, but they are imperfect to interpret it [10]. Moreover, learning with molymod modeling is potentially causing misconceptions if teacher or lecturer do not emphasize that molymod can only represent covalent bonds but molymod is not suitable to represent ionic bonds[17]. UMS as transitional reasoner (T) wrote the Lewis structure based on number of valence electrons from subshell configuration, but did not consider alkaline characteristic of elements. The alkalinity of elements affects its tendency to share electrons or to transfer electrons in forming chemical bonds. The Ca element from alkaline earth metal group and the Cl element from the halogen group, has high electronegativity difference over 1.7. It causes the Ca element to release 2e produces Ca2+ cations while the two Cl elements each other accept 1e produces Cl- anions. The interaction between the Ca2+ cation and Cl- anion is referred to an electrostatic force or forming ionic bonding as follows:
4.6 Q12. Magnetism Properties

Electron configurations of Al and Cr were written by 14.3% UMS as concrete reasoner (C) and 32.1% UMS as transitional reasoner (T) by filling electron did not obey the stability rules for filling full or half full in orbitals. The following is a comparison of their answer:

| UMS’ Scientific Reasoning Ability | Answer about Magnetism Properties |
|-----------------------------------|-----------------------------------|
| UMS as concrete reasoner (C)      | UMS as transitional reasoner (T) |

UMS as concrete reasoner (C) and UMS as transitional reasoner (T) answered based on the number of unpaired electrons which affected on magnetic strength. Those students do not have the ability to interpret spin value of the electrons which affect magnetic strength of the element. Trifone stated that students with concrete reasoning abilities tend to interpret difficulty non-observable object for example spin value of electrons [9]. A different result is shown by UMS as transitional reasoner (T) who already have the ability to interpret the effect of the spin value on the magnetic strength of the elements. They calculated the total spin value of the unpaired electrons for Al equal to +1/2, while the spin value of the unpaired electrons for Cr is +2, so Cr is stronger magnetism than Al. The majority of UMS wrote electron configurations did not obey stability rules of the full or half full in orbital. The Cr configuration should be written as [Ar] 4s\(^{1}\) 3d\(^{5}\) with electron spin value equal to +3.

4.7 Q3. pH calculation of acid and base mixture

UMS as concrete reasoner (C) as many as 7.1% and UMS as transitional reasoner (T) as many as 3.6%, determined pH of acid and base mixture without stoichiometric calculations. Based on its percentage, indicates that only a few students can not complete stoichiometric calculations through numeric data as moles of substances. Stoichiometric calculations are required to determine the formula which is used to calculate the pH of acid and base mixture.

The majority of UMS had the ability to solve stoichiometric calculation problems. It means that UMS had master algorithmic knowledge so easy to solve stoichiometric calculation. This is supported by Okanlawon described that stoichiometric problems using numerical data can solved by students easily [18], if do not involve complex understanding on particulate phenomena. The following is an example of UMS as concrete reasoner (C):

![Figure 9. UMS as concrete reasoner (C) understood on pH calculation](image-url)
The majority of UMS easily determined limiting reactant through numerical data. The moles of the limiting reactant are used to determine the moles of the product. It is used to determine formula the pH calculation of strong acids and remaining weak bases.

4.8 Q4. Colloidal Properties
Colloid requires students’ conceptual understanding on microscopic aspects. Colloids are learned by students by memorizing [19] and learned by discussion method is not effective in directing students to construct concepts independently [20]. Colloid as contextual material should be easily understood by students, but learning not emphasized the visualization of microscopic aspects. It usually makes students not reach correct understanding. The findings of several incorrect understandings of UMS as concrete reasoner (C) and UMS as transitional reasoner (T) are shown on table 2. The sampling answers of UMS who understood colloidal properties were not accepted scientifically on following figure:

**Figure 10.** The answer of UMS as transitional reasoner (T) on colloidal Properties

Based on their description answer on colloidal properties, their understanding about kinetic phenomenon as freely movement of colloidal particles with gas-dispersed phase and gas-dispersion medium. One of colloidal characteristic can distinguished between dispersed phase and dispersion medium [21], so that there is no classification of colloids with the same dispersed phase and dispersion medium as gas states [14]. Gas in the gas medium are not as colloidal particle but it form gas mixture, because they can not distinguished from one another in the same gas medium. In addition, examples of the kinetic properties are bubbles which less precise. The kinetic properties truly represented by Brownian motion are zigzag movement of colloidal particles which can only observed by ultra microscopes as follows:

**Figure 11.** Brownian Motion (reasearchgate.net)

5. Conclusion
The understanding of microscopic representations of mathematics students classified low, because the majority of UMS’ ability to reason at concrete and transitional level. Their inability to construct interpretations of microscopic phenomena makes their understandings unacceptable scientifically. This can be seen in the stoichiometric calculation problems with microscopic representation data, which is difficult for them to solve. However, they tend to easily solve calculation problems with numerical data as moles of substance. In general chemistry learning, requires innovation to visualize microscopic
aspects, so that UMS at concrete reasoning and transitions reasoning have the ability to interpret microscopic phenomena which is not observed by naked eyes.

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