Dynamic Equilibrium: The Conception of a Prospective Chemistry Teacher

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ABSTRACT
In this study, prospective teachers were given two videos to observe and identify the changes that occurred. From the video, it can be seen how the prospective teacher's understanding of the analogous concept of dynamic equilibrium is. This study used a five-tier multiple-choice (FTMC) instrument, which is a modification of another diagnostic test to identify the student's profile of misconception in chemical equilibrium, especially in the concept of dynamic equilibrium. The conclusion that can be drawn is that the concept of dynamic equilibrium is still not fully mastered by prospective teachers at all levels, especially the many categories of misconceptions obtained. The concept of dynamic equilibrium is still a lot of misconceptions if a reactant and product conditions show different amounts. The data shows that for the appropriate conception category, it is 1.18%-1.19%, and misconceptions are 92.94%-98.81%. The conception of something can be further analyzed by looking at its microscopic depiction. This can be diagnostic to learn where a misconception can occur.

Keywords: *Equilibrium, Conception, Prospective Teacher, Chemistry.*

1. INTRODUCTION

Many studies have studied the difficulty level of various material themes in chemistry. The results obtained are that the Chemical Equilibrium material is the most challenging material according to students and 100 chemistry teachers who are randomly selected [1], [2]. The concept of dynamic equilibrium is a basic concept that one must master before understanding chemical equilibrium. Dynamic equilibrium is an essential concept in chemistry. But what is dynamic equilibrium exactly? How can something be dynamic but also at equilibrium? Have students mastered it correctly?

Chemical reactions can either go in both directions (forward and reverse) or only in one direction. The ones that go in two directions are known as reversible reactions, and you can identify them by the arrows going in two directions. In chemistry and physics, a dynamic equilibrium exists once a reversible reaction occurs. Substances transition between the reactants and products at equal rates, meaning there is no net change. Reactants and products are formed at such a rate that the concentration of neither changes. It is a particular example of a system in a steady state. These are the things that students must master before understanding the concept of chemical equilibrium.

Dynamic equilibrium is an example of a system at a steady state. This means that the variables in the equation do not change over time (because the reaction rates are the same). Therefore, if you look at a reaction in dynamic equilibrium, it will look like nothing is happening because the concentration of each substance remains constant. However, the real reaction continues.

Dynamic balance doesn't only happen in chemistry labs; we've even seen many examples of dynamic balance every time you drink soda. In a closed soda bottle, carbon dioxide is in a liquid/water phase and a gas phase (bubbles). The two phases of carbon dioxide are in dynamic equilibrium inside a closed soda bottle because gaseous carbon dioxide dissolves into the liquid state at the same rate that the liquid form of carbon dioxide is converted back to its gaseous form.

These examples in everyday life need to be understood by a prospective teacher who will teach dynamic equilibrium material to his students. For this reason, it is necessary to know how a prospective teacher's conception of dynamic equilibrium is.

In this study, prospective teachers were given two videos to observe and identify the changes that occurred. From the video, it can be seen how the prospective teacher's understanding of the analogous concept of dynamic equilibrium is. Furthermore, this study used a five-tier multiple-choice (FTMC) instrument, which is a modification of another diagnostic test to identify students' profiles of misconception in chemical equilibrium, especially in the concept of dynamic equilibrium.

The five-tier multiple-choice (FTMC) diagnostic test, the first level of each multiple-choice, consists of content questions that have five options. The second and fourth levels are the levels of confidence in the answer given in the first and third sections. The third level consists of content questions that have five options about the reason for the first tier. And the last tier is a description of the conception that prospective teachers have about the concept in question. This picture is a microscopic (or symbolic) picture that occurs in the concept. From this description, it will be more understandable about the conception of prospective teachers.

FTMC is used to diagnose the conception of teacher candidates more clearly. Because this test combines multiple-choice questions with pictures, prospective teachers can determine their answers if the multiple-choice questions do not provide a satisfactory answer through the drawing level. With this test, more data can be generated about prospective teachers' conceptions and find out which parts of the concepts students have understood and which have not. In addition, the level of drawing can provide information about the reasoning abilities of prospective teachers and how to communicate their understanding through the drawings they make.

The video used is taken from the North Carolina School of Science and Mathematics (NCSSM Online) dynamic equilibrium video. The video consists of 2 activities that describe dynamic equilibrium by using water transfer from one vessel to another. Two different depictions but with the same concept, dynamic equilibrium. From these two activities, prospective teachers are asked to identify the concepts that occur by answering the FTMC and describe them microscopically so that the prospective teacher's conceptions of dynamic equilibrium can be identified.

2. METHODS

The method used in this research is the descriptive method. The participants in this study were prospective chemistry teachers 4th (CE19) and 6th (CE18) semesters of the Unesa Chemistry Department. Each subject consists of 85 people with heterogeneous academic levels. The conception data of prospective teachers were collected by using an online test. The instrument used to identify student profile misconceptions is five-tier multiple-choice (FTMC), which was developed by modifying the same procedure [3].

Prospective teachers are given FTMC at a certain time through the link provided. There are two videos that must be watched. Then prospective teachers are asked to answer multiple-choice questions about the results of observations, reasons, and level of belief and microscopically describe the existing concepts.

The data were analyzed using the interpretation of conceptual data to obtain the appropriate concept categories, fewer concepts, wrong concepts, and misconceptions. In addition, the microscopic images made were analyzed further to understand the thinking skills of prospective teachers about concepts.

3. RESULTS AND DISCUSSION

From the results obtained, it is known that there is no significant difference between the interpretations of CE19 and CE18. This can be seen from the following statistical results:

Table 1. Statistical test of the results of conception CE18 and CE19 against videos 1 and 2 about a dynamic equilibrium

	Video 1	Video 2
Mann-Whitney U	3568,500	3367,500
Wilcoxon W	7223,500	6937,500
Z	-,009	-1,489
Asymp. Sig. (2-tailed)	,993	,136

It is known that the value of Asymp.Sig. > 0.05, so it can be said that there is no difference in learning outcomes between CE18 and CE19 in videos 1 and 2. From the results above, it can be obtained information that the conception of dynamic equilibrium at CE18 and CE19 is not different even though they are at different levels of teacher preparation by one year. What's further about this result is that the conception that was held did not change during the one year of learning that followed.

Observing the interpretation of the CE18 and CE 19 conceptions, the results were obtained according to Table 2.

Table 2. The percentage of interpretation of prospective teachers' conceptions in video 1

Prospective teacher	Interpretation of conception (%)			
	appropriate	less	Wrong	misconception
CE19	35.71	13.10	00.00	51.19
CE18	45.88	1.18	00.00	52.94

In video 1, the data shows that at CE19 for the appropriate conception category, it is 35.71%, and misconceptions are 51.19%. In comparison, at CE18, it is 45.88% for the appropriate conception category and 52.94% for the misconception category. From these results, it can be seen that the concept of dynamic equilibrium in video 1 can be obtained well by the respondents.

In video 1, the concept of dynamic equilibrium is shown by transferring a certain amount of water from vessel 1 to vessel 2. Water is transferred using a beaker of the same volume. From the video, respondents can easily identify the concept of dynamic equilibrium because after some time, the amount of water in vessel 1 is the same as in vessel 2.

Figure 1 Transfer of water from vessel 1 to vessel 2 using a beaker of the same volume in video 1.

However, there are still several respondents who experience misconceptions from the observations made. Misconceptions occur in tier 3 of FTMC, which are related to the reasons given for the phenomena in video 1. The reasons given are related to the rate of displacement that occurs. Dynamic equilibrium occurs only in reversible reactions. This can be easily identified from the video by looking at the change in the amount of water from vessel 1 to vessel 2, or vice versa. Dynamic equilibrium also occurs when the rate of the forward reaction is equal to the rate of the reverse reaction. This is identified from the video by looking at the use of two beakers of the same volume. They conclude that both rates are the same and do not change, or the forward rate is the same as the reverse rate so that the system is in equilibrium.

The following are the results obtained on the concept of dynamic equilibrium in video 2.

In video 2, the data shows that at CE18 for the appropriate conception category, it is 1.18%, and misconceptions are 92.94%. In comparison, at CE19, it is 1.19% for the appropriate conception category and 98.81% for the misconception category. This result is very different from the same conception, dynamic equilibrium, in video 1. Therefore, the concept of dynamic equilibrium in video 2 cannot be obtained well by the respondents.

Figure 2 Transfer of water from vessel 1 to vessel 2 using beakers of different volumes in video 2.

Table 3. The percentage of interpretation of prospective teachers' conceptions in video 2

Prospective teacher	Interpretation of conception (%)			
	appropriate	less	wrong	misconception
CE19	1.19	00.00	00.00	98.81
CE18	1.18	2.35	3.53	92.94

In video 2, the concept of dynamic equilibrium is still demonstrated by moving a certain amount of water from vessel 1 to vessel 2. However, water is transferred using a beaker with a different volume. From the video, respondents have difficulty identifying the concept of dynamic equilibrium. This is because after some time, the amount of water in vessel 1 is not the same as in vessel 2.

The conception held by the respondent is that when dynamic equilibrium occurs, the amount of water that moves between vessels 1 and 2 is the same, so when seeing a different amount of water being moved, the respondent does not state the dynamic equilibrium condition that occurs. The misconception is seen in Tier 2 FTMC, which is the section on the reasons for the conditions observed in Video 2. Almost all respondents answered that this condition is not a dynamic equilibrium because the amount of water is not the same, so the transfer rate is not the same.

Further explanation can be seen from the last tier of FTMC, which microscopically describes the conditions in Video 1 and Video 2.

Dynamic equilibrium only occurs in reversible reactions, and it’s when the rate of the forward reaction is equal to the rate of the reverse reaction. These equations are dynamic because the forward and reverse reactions are still occurring, but the two rates are equal and unchanging, so they’re also at equilibrium.

This conception is the same as the depiction of the CE8-42. The depiction made can be seen that when the displacement is carried out, it produces a constant change when the transfer rate is also constant even though the depiction in video 2 produces different water levels between vessel 1 and vessel 2.

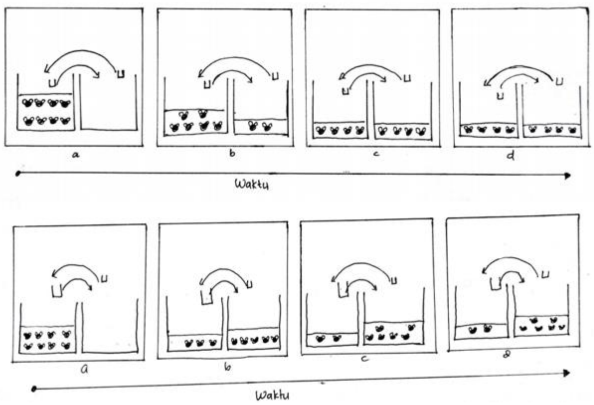

Figure 3 Microscopic images of the dynamic equilibrium concept in video 1 (top) and video 2 (bottom) by CE8-42.

This is indicated by the conclusions given, namely: in video 1, the rate of forward and reverse reactions is the same, the concentration is the same and does not change after a certain time. In video 2, the rates of forwarding and reverse reactions are the same, the concentration of products and reactants does not change again after some time even though the amount of concentration is not the same, but in equilibrium, the number of products and reactants has no effect so that in video 2 it is included in equilibrium.

From the conclusions given in accordance with the microscopic depiction given. This picture can better explain the conception that is head of dynamic equilibrium. However, a different depiction is shown by CE8-18.

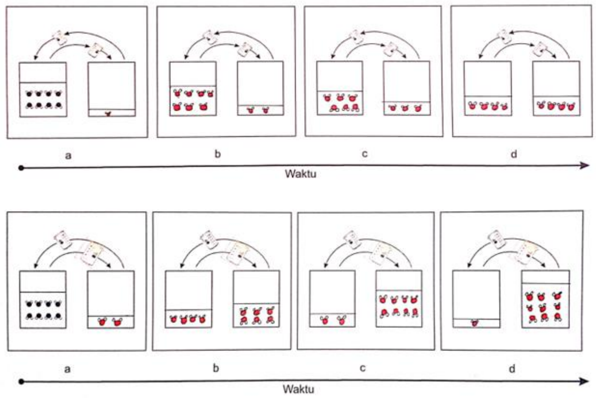

Figure 4 Microscopic images of the dynamic equilibrium concept in video 1 (top) and video 2 (bottom) by CE8-18.

From the microscopic depiction carried out, it can be seen that CE8-18 states that the conditions of video 1 are different from those of video 2. Due to the difference in water levels in vessels 1 and 2 in video 2, CE8-18 states that the conditions of video 2 are not dynamic equilibrium conditions. Of course, this is a misconception. However, CE8-18 can still microscopically describe how an equilibrium system occurs by depicting the same number of particles all the time running on the system.

This is indicated by the conclusions given, namely: in video 1 reached a point where the water level in both containers is the same. At this point, the rate of the forward reaction (rate of the reaction to the products) is equal to the rate of the reverse reaction (rate of the reaction to the reactants). While in the second video, the water level is higher in the product than the reactants, in this case, it is said that the equilibrium is far towards the product with a large reaction rate towards the front (reaction rate to the product).

Another misconception occurs, like CE8-31. The misconceptions they have can also be seen from the microscopic depiction they do.

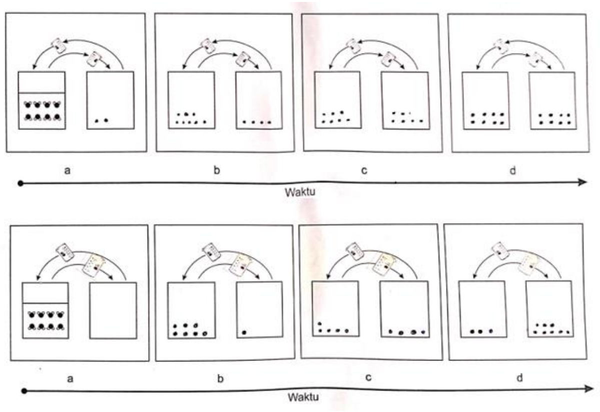

Figure 5 Microscopic images of the dynamic equilibrium concept in video 1 (top) and video 2 (bottom) by CE8-31.

The misconceptions they have can also be seen from the microscopic depiction they do. The depiction is carried out without paying attention to the changes that occur between vessels 1 and 2 so that it does not show the correct conception of dynamic equilibrium. This can also be seen from his conclusions; namely, this is because, in video 1, there is a situation wherein vessel 1 (reactants) and vessel 2 (products) have the same speed and reach a state where the amount of water obtained is the same. Moreover, CE8-31 cannot describe microscopically how a dynamic equilibrium system can occur. It can be seen from the amount of substances that are not the same all the time running on the same system.

Drawing tests need to be added to the diagnostic test because first, drawing can also be used to explain thought patterns and as a form of communication, regardless of discipline; second, drawing is a process skill that is part of the practice of science, used in generating hypotheses, designing experiments, visualizing and interpreting data, and communicating results [4], [5], [6] and third, drawing is a constructive and motivating activity because it combines direct activity and the thought of the moment [6].

Mental models have an essential role in the development of conceptual and scientific reasoning. Visualization of mental models can help teachers and students understand the process of knowledge formation. Analysis of changing mental models is needed to gain a better understanding of student needs to help teachers design effective learning. Visualization of mental models can be measured through the process of problem-solving, interviews, and drawing as well as analyzing student answers when solving problems and then classifying them according to predetermined mental model indicators. Chemistry learning requires much intellectual thought and discernment because the content is replete with many abstract concepts. Concepts such as dissolution, particulate nature of matter, and chemical bonding are fundamental to learning chemistry [9], [10], [11].

4. CONCLUSION

The learner's conception of a topic relates to all kinds of ideas that have been stored in his long-term memory. Therefore, new material will connect with previous ideas, and this can lead to confusion and misunderstanding. For this reason, the concept of dynamic equilibrium must be improved first so that the concept of chemical equilibrium material will be better. From the data obtained: The concept of dynamic equilibrium is still not fully mastered by prospective teachers, especially the many categories of misconceptions that are obtained. The concept of dynamic equilibrium is still a lot of misconceptions if a reactant and product conditions show different amounts. The conception of something can be further analyzed by looking at its microscopic depiction. This can be diagnostic to learn where a misconception can occur.

AUTHORS CONTRIBUTION

All authors conceived and designed this study. All authors contributed to the process of revising the manuscript, and at the end all authors have approved the final version of this manuscript.

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