# The Implementation of Conceptual Change Approach to Teach Nature of Science and Cellular Respiration Concepts

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**Abstract.** The classroom action research aimed to investigate the way to implement the conceptual change approach in order to enhance students' views of Nature of Science (NOS) as well as their understanding on cellular respiration concepts. The research question being investigated is How to implement the conceptual change approach to teach NOS and Cellular Respiration Concepts? The research participants are grade X science students (n=15) registered in English Program (EP) of a high school in Phitsanulok, Thailand. The teaching intervention had been conducted in three repetitive cycles of action research: planning, acting, observing, and reflecting, along with utilization of a series of instrument: the Nature of Science Questionnaire (NOSQ) and Cellular Respiration Questionnaire (CRQ), nine 55-minute lessons, semi-structured observations, and semi-structured interviews. The result of content analysis and triangulation advocated that the teaching intervention should consists of 5 phases of teaching, namely eliciting preconceptions, presenting common misconception, presenting targeted concepts, raising the status of targeted concepts, and reflecting on targeted concepts. The teaching necessarily gives equal attention to both NOS views and cellular respiration concepts, particularly the activities to raise the status of targeted concepts.

## INTRODUCTION

The 21st century is the era of globalization and internalization in which the societies are highly influenced by the rapid development of science and technology. As the influence of science on society become increasingly high, particularly on personal and political decision making, there is also an increasing need for societies to develop a proper understanding of the knowledge of science as well as the knowledge about science. The former refers to the understanding of scientific concepts, meanwhile the latter refers to the understanding of the nature of scientific knowledge (NOS). The importance of understanding scientific concepts along with the nature of scientific concepts (NOS) is due to the fact that societies wouldn't be able to realize the life-enhancing potential of science unless they understand the nature of scientific knowledge (NOS) and acquire basic scientific habit of mind (AAAS, 2013). Furthermore, the understanding of both types of knowledge has also been considered as crucial components for the acquisition of scientific literacy (NSTA, 1982; Lederman, 2002; AAAS, 2014), which is the ability to engage with science-related issues and with the ideas of science in order to make informed decisions regarding the issues they faced (OECD, 2015).

Educational reforms in Thailand acknowledges the importance of understanding the knowledge of science and the knowledge about science by setting the requirement to understand scientific concepts (i.e. Strand 1 – 7) along with the requirement to understand the nature of science aspects (i.e. Strand 8) (The Ministry of Education, 2008). Accordingly, science teachers in school are required to teach the NOS aspects along with the teaching of science content knowledge. In this sense, the teaching of science concepts in strand 1 to strand 7 are required to be coupled with the NOS aspects from strand 8. Despite the requirement to teach NOS aspects along with the teaching of science subjects, many science teachers only focus on teaching science content as the time allocation is

considered not enough if they have to teach NOS aspects in their teaching. Furthermore, many teachers have chosen not to teach the NOS aspects since they consider that although NOS aspects are included in the curriculum, it will not be tested in the national test. The ignorance of NOS aspects in science classroom may cause the inadequate views of NOS among Thai students as have been reported by many researchers (Buaraphan, 2010; Sangsaard, Thathong, and Chapou, 2013).

Science educators have been trying to improve students NOS views through many ways, including implicit approach, explicit approach, explicit-reflective approach, and conceptual change approach. Implicit approach is based on the assumption that the genuine understanding of NOS is the result of engagement in inquiry process. However, it is now well documented that engagement in inquiry is not necessarily result in improved understanding of NOS (Abd-El-Khalick, 2012; Sandoval and Morrison, 2003). Explicit-reflective approach has been viewed as an effective approach in improving students NOS views, since the NOS aspects are addressed explicitly during the teaching and learning. Furthermore, structured opportunities to assess students' views of the NOS aspects are also provided in the last session of learning. Thus, it provided a better support for students to learn the aspects of NOS (Abd-El-Khalick, 2012; Abd-El-Khalick and Akerson, 2009). An empirical study had been conducted to assess the effectiveness of implicit, explicit-reflected, and conceptual change approach in enhancing students' views of NOS (Cil, 2014). It was advocated that the superiority of conceptual change approach is due to the set of guidelines offered by the approach for students to grasp the concepts, such as identifying common misconceptions, activating students' misconceptions, providing a scientifically correct explanation, and giving students the opportunity to practice the correct explanation (Cil, 2002). It was found as a superior approach in enhancing students' views of NOS compared to other approach. Accordingly, this study aimed to implement the conceptual change approach in enhancing students' views of NOS as well as cellular respiration conceptions.

The research question to be addressed in this study is "How to teach nature of science and cellular respiration concepts through the implementation of conceptual change approach?" Accordingly, the finding of this study would be a source of information on how conceptual change approach can be implemented to enhance students understanding of science and about science, in this case is cellular respiration and nature of science respectively.

The conceptual change approach in this study is the teaching strategies which provides guidance for students to gain scientifically accepted ideas through 5 main steps, namely eliciting preconceptions, presenting common misconceptions, presenting targeted concepts, raising the status of targeted concepts, and reflecting on targeted concepts. The Nature of Science views in this study refers to the response of students regarding 5 aspects of NOS which is addressed through NOS Questionnaire (NOSQ). The 5 aspects of NOS being addressed including scientific knowledge is tentative, scientific knowledge is based on empirical evidence, scientists are creative, science is a complex social activity, and science has global implication. Meanwhile, the cellular respiration conceptions in this study refers to students' response on cellular respiration questionnaire (CRQ) regarding the concept of energy, relation of respiration and breathing, aerobic respiration, and anaerobic respiration.

## RESEARCH METHODOLOGY

### Research Design

The research method applied in this study was a classroom action research which based on qualitative paradigm and was conducted in three cycles, in which each cycle consists of the 4 essential steps of action research, starting from planning, acting, observing and reflecting. The result of reflection in cycle I was used as the basis to do the planning in cycle 2, and the result of reflection in cycle II was used as the basis to do the planning in cycle 3. At last, the result of reflection in cycle 3 was used to develop the suggestion on how to teach both nature of science and cellular respiration concepts under the framework of conceptual change approach.

### Research Participants

The participants of this study are Grade X science students (n=15) registered in English Program (EP) of a high school in Phitsanulok Province, Thailand. In order to join the EP, the students are required to pass the general English test to ensure that their language skills are sufficient to learn by using English as the medium of

communication. All the participants have been joining the EP since grade VII, which reflects the fact that students have the experience in learning with foreign teacher for at least three years.

## Researcher Role in School

Biology instruction for EP students in grade X is conducted in 3 teaching periods per week. In each week, students interact with a foreign teacher for 2 teaching periods, and with a Thai teacher for 1 teaching period. The teaching and learning process with foreign teacher is conducted by using English, meanwhile the teaching and learning process with Thai teacher is conducted by using Thai language. In this study, researcher act as a foreign teacher and took all the 3 teaching periods in each week. Thus, the teaching and learning throughout the intervention was conducted in English.

## Research Instrument

Instruments for data collection which had been used during the study including nine 55-minutes lesson plan, Nature of Science Questionnaire (NOSQ), Cellular Respiration Questionnaire (CRQ), semi-structured interview and semi-structured observation sheet. The lesson plan was used as guideline to conduct 9 teaching periods in intervention which last for 55 minutes in each period. The NOSQ consisted of open ended questions and cover 5 aspects of NOS, namely scientific knowledge is based on empirical evidence, scientific knowledge is tentative, scientists are creative, science is a complex social activity, and science has global implication. The CRQ was used to assess students' cellular respiration conceptions. It consisted of multiple choice questions with several possible answers, followed by requirement for students to justify their chosen answer. The administration of NOSQ and CRQ were continued with semi-structured interview with 20% of the participants. It was aimed to gain more information regarding students' conceptions, and also to validate students' responses on the questionnaires. Semi-structured observation was conducted to gain data on how the teaching intervention had been conducted. The observation also aimed to ensure that the implementation of teaching intervention satisfy the guideline of teaching for conceptual change.

## Data Collection

The teaching intervention was conducted in 9 teaching periods, in which each period last for 55 minutes. The implementation of conceptual change approach was observed by using the semi structured observation sheet. The focus of observation including the strategies used to elicit students' preconceptions, to present common misconceptions, to present plausible and intelligible explanation, to provide activities for participants to practice their understanding, and to encourage social environment for learning. Participants' views of NOS were assessed by using Nature of Science Questionnaire (NOSQ) which was administered before and after teaching intervention, meanwhile their understanding of cellular respiration was assessed by using Cellular Respiration Questionnaire (CRQ) which was also administered before and after the teaching intervention. The development of students' views of NOS was analyzed through students work.

## Data Analysis

Students' responses on both NOSQ and CRQ were analyzed through content analysis which involved reading and judgement. For the analysis process, students' answers on the questionnaires were retyped verbatim in group based on the aspect of NOS it addressed. After the grouping of students answer, researcher then read the answer thoroughly and pick up the main points from each answer which will then be used as the basis for categorization. The categorization was conducted exhaustively to cover all the patterns of students' responses. After categorizing, the data were reread and were reviewed to find out the emerging patterns of students' responses. Following the

exhausted categorization of students' responses were the process of finding the meaning behind the patterns of the data.

Credibility of the research was ensured by implementing method triangulation. The utilization of different data collection methods, i.e. questionnaire, interview, and observation, had enable compensation of their individual limitation and exploitation of their respective benefits. Thus, a clear and plausible answer to the research question is possible to be achieved. The data had also been subjected to peer debriefing, in which research data, final report, and general methodology had been examined cooperatively by a scientist and a science educator.

Students' views related to NOS aspects were categorized into three main categories, namely naïve, mixed, and informed views, as follows:

a. Informed, refers to more desirable NOS views which are aligned with the NOS aspects as explained in science standard documents.
b. Mixed, refers to responses which consists of parts that are aligned with the NOS aspects explained in the science standard documents and parts that are not aligned with the documents. In this category, the statements are neither naïve nor informed as it is a combination of different, and at times contradictory, views of NOS aspects.
c. Naïve, refers to responses which are not aligned with the NOS aspects explained in science standard documents.

Students' responses on cellular respiration questionnaire (CRQ) were categorized into 5 categories as follows:

a. Sound Understanding (SU) refers to the responses that included all component of the validated responses.
b. Partial Understanding (PU) refers to the responses that included at least one of the components of validated responses.
c. Partial Understanding with Specific Misconception (PUSM) refers to responses showed understanding of the concept, but also made a statement which demonstrated a misunderstanding
d. Specific Misconception (AC) refers responses that included illogical or incorrect information
e. No Understanding (N) refers to responses that only repeated the question; contain unclear response; or left the response blank.

## RESULT

### Pre-Intervention

The analysis on NOSQ pre-intervention showed that majority of students hold naïve views regarding the NOS aspects being addressed in the questionnaire. Most students hold naïve view regarding tentativeness of scientific knowledge (93%) and the global implication of scientific knowledge (93%). The participants also hold naïve view regarding empirical (67%), creativity (67%), and social aspect (87%) of scientific knowledge.

The analysis on CRQ pre-intervention showed that majority of students posed partial understanding (60%) and no understanding (27%) regarding the concept of energy. Only few students (7%) could explain the relation of respiration and breathing, the process of aerobic respiration, and the process of anaerobic respiration.

### Cycle I

The action in cycle I was conducted in 3 periods of teaching, in which each period last for 55 minutes. The teaching and learning were implemented in 5 main phases, namely eliciting preconceptions, presenting common misconceptions, presenting targeted concepts, raising the status of targeted concepts, and reflecting on concepts learned. Elicitation of preconceptions was conducted by introducing the question through concept cartoon. Students were asked to express their ideas, whether or not they agree with the statements provided on the concept cartoon. Students' were then divided into several groups to discuss provided statements regarding energy, cellular respiration and breathing, and nature of science. Common misconceptions were then presented in table, followed by explanation on why those conceptions are incorrect. Scientifically accepted conceptions were then presented by utilizing power-point and animation. The effort to raise the status of targeted concepts was conducted by directing the students to compare the amount of energy contained in different kinds of food by using Calorymetry Virtual Lab. In the last session of learning, students in each group discussed what they have learned and presented it in front of the class.

The observation on the implementation of conceptual change approach showed that several practices still need to be improved, including the strategy to elicit students' preconception. The elicitation of students' ideas had covered three different topics at once, including the concepts of energy, cellular respiration, and the nature of science. It appeared to have made students overwhelmed, which may cause them to use more time during the group work. While presenting the common misconception, students were encouraged to share their ideas, but they appeared to be reluctant to share their ideas. It might due to their feeling of worry to give wrong answer. In the presentation of scientific concepts, the use of power point and animation had been beneficial in helping students in the teaching and learning process. In the activity to raise the status of targeted concepts, students' utilized the Calorymetri Virtual Lab, and they could successfully count the amount of energy contained in several types of food. Although the activity had been successfully implemented to raise students' cellular respiration conceptions, the connection to the nature of science aspects had been ineffective.

## Cycle II

The planning phase of cycle II was conducted by rearranging the lesson plan based on the result of reflection in Cycle I, including development of a concept cartoon to focus students' attention on a topic (i.e., NOS aspect), power-point and animations to facilitate the intelligibility and plausibility of targeted concepts, and a hole-paper activity to facilitate the fruitfulness of both NOS and cellular respiration conceptions. The acting phase of cycle II was conducted by implementing the 5 main stages of conceptual change approach. Elicitation of students' preconceptions was conducted by utilizing a concept cartoon asking what science is. Researcher directed students to discuss in group and write down their ideas. Students discuss in group and came up with one definition of science in each group. They tend to define science either as a body of knowledge or as the process to find the knowledge. Thus, researcher guided students to define science as both the body of knowledge and the process to find the knowledge. As the definition of science have been explained, researcher focus the students to pay attention to the aspects of science which would be learned. Misconception regarding the use of creativity, tentativeness of science, and social aspect of science were explained by utilizing the display and accompanied by researcher's explanation on why the statements provided are incorrect. Researcher continued to explain the targeted concepts explicitly, started by explanation of the accepted notion of NOS and followed by the example to support the NOS notions. After explaining the aspects of NOS, researcher continued with the explanation of glycolysis and fermentation. The presentation of glycolysis and fermentation was done by highlighting common misconceptions regarding the concepts, in which researcher started with question "where the fermentation takes place in the cell?" Students were directed to write down their ideas on the worksheet and then compared their answers with their peers.

Researcher then presented the concepts by utilizing power-point and followed by the presentation of animation to help students gain visualization of the process. In order to gain the status of targeted concepts, students were directed to work on the hole picture activity. Each group were directed to find out the shape of colored paper inside the board and relate their activity with the work of scientists in finding knowledge. Researcher gave explanation for students that the paper inside the board can be seen as a knowledge we want to know, e.g. the process that occurs in the cell. Meanwhile, the holes on the board can be seen as the data points which enable scientists to collect the data they need for drawing conclusion. After working on their board, students were directed to draw the process of glycolysis and fermentation. They worked in group and discussed to highlight the important point of the process.

Reflection on the concepts learned was conducted by inviting students to answer the questions as have been explained during the learning process. Researcher invited students to share what they have learned during the lesson. Following students explanation on what they have learned, researcher then gave questions about the important points of the learning and encourage students to share their ideas. Students were then directed to write down the conclusion of the learning on their worksheet.

The observation showed that the use of audiovisual materials had helped to make students paying more attention to the lesson. The grouping of students had also facilitated students to share their ideas in finishing the task. Moreover, while students sat in group, they could discuss one another and encouraged the group member to give answer whenever questions being asked by researcher. Based on the action which have been conducted and the result of observation, some improvements had been reached, such as the use of sufficient time for elicitation of students' ideas, the ability of covering both NOS and cellular respiration concepts, and the giving of reward to encourage students to participate more in answering researchers' question. The elicitation of students' preconceptions in this cycle was focused on the NOS by directing students to answer the question of what science is.

This way of conducting the elicitation phase of learning had been beneficial in helping students to be more focus on the topic being addressed. It could be seen from the result of students works in which they could relate the four aspects of NOS with their activity to construct the shape of colored paper. Being focused on a topic in the elicitation phase of learning perhaps had helped students to focus their attention on the explanations provided in subsequent phase of learning. The application of ideas was conducted by directing students to work on two tasks. In the first task, students were directed to work on the Hole Picture Activity and to find out how their activity can relate to the aspects of NOS. In the second task, students were directed to create a model of glycolysis and fermentation. The former task aimed at letting the students to think about NOS aspects have been explained earlier, meanwhile the latter aimed at giving the chance for students to improve their understanding of cellular respiration. This activity appeared to had provided a chance for students to actually think about how the aspect of nature of science can be connected to the content material being learned.

## Cycle III

The planning phase of cycle III was conducted by rearranging the lesson plan based on the result of reflection in Cycle II. The use of concept cartoon had been found efficient in encouraging students to share their ideas regarding the concepts in cycle II. Thus, a concept cartoon were prepared to be used in eliciting students' ideas on cellular respiration concepts. Animation and stop motion video were also prepared to support the teaching and learning. Furthermore, a model of electron transport chain (ETC) was constructed by researcher using colored paper in order to give opportunity for students to use their understanding in explaining the process of electron transport. The history of science was also prepared to help students gained more ideas in targeted NOS aspects. The acting phase also followed the 5 steps of conceptual change teaching approach. Elicitation of preconception was conducted by deploying concept cartoon asking a common substrate for Krebs cycle. Animation of aerobic respiration and Krebs cycle was followed by the presentation of the history of Krebs cycle. The process of electron transport was also explained through the presentation of animation. During the presentation, researcher stopped in some point and gave questions to focus students' attention on the important point of the process. In the last session of the presentation, researcher again explained the aspect of nature of science and highlighted the aspect of NOS that scientific knowledge has a global implication. In order to raise the status of targeted concepts, students worked in group to explain the process of Krebs cycle and the aspects of NOS which are reflected from the history of Krebs cycle. In the last session of instruction, students reflected on the concepts learned by answering questions and group discussion.

## Post-Intervention

The analysis on NOSQ post-intervention showed that majority of students improved their views regarding the NOS aspects being addressed, with the major improvement regarding tentativeness in science and creativity in science. All students improved their view that scientific knowledge can change (tentativeness of science), and only 7% of students retained their naïve view that creativity can't be used in the development of scientific knowledge. The categorization of students' NOS views before and after the teaching intervention were shown in the Table 1.

**TABLE 1**. Categorization of Students' NOS Response on 5 Aspects of the NOSQ Pre and Post Intervention

| NOSQ | Empirical Evidence | | Creativity in Science | | Tentativeness | | Social Aspects | | Global Implication | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre (%) | Post (%) | Pre (%) | Post (%) | Pre (%) | Post (%) | Pre (%) | Post (%) | Pre (%) | Post (%) |
| Informed | 0 | 13 | 0 | 40 | 0 | 13 | 0 | 13 | 0 | 13 |
| Mixed | 33 | 73 | 33 | 53 | 7 | 87 | 13 | 73 | 7 | 73 |
| Naïve | 67 | 13 | 67 | 7 | 93 | 0 | 87 | 13 | 93 | 13 |

The analysis on CRQ post-intervention showed that majority of students had improved their understanding regarding cellular respiration concepts. Many students were categorized as posing sound understanding regarding the concepts of energy, in which they could explain the transferability and transformability of energy (33%). However, few students could explain the relation of breathing and respiration (20%). The analysis of students' responses regarding the process of aerobic respiration showed that students could recognized the product of glycolysis (87%), the amount of product produced in glycolysis (40%), the changes of carbon during Krebs cycle (73%), as well as the function of electron transport chain (67%). Students' responses regarding the process of anaerobic respiration also showed a positive result, in which students could recognize the fate of pyruvate under insufficient condition of oxygen (87%). Students also recognized the advantages (67%) and the disadvantages (60%) of fermentation.

## DISCUSSION

The result of intervention in this study showed that conceptual change approach could be implemented in teaching nature of science and cellular respiration concepts with the aim of giving equal attention to both types of knowledge. The teaching intervention had been conducted in 5 main phases, namely eliciting preconceptions, presenting common misconceptions, presenting targeted concepts, raising the status of targeted concepts, and reflecting on targeted concepts. The implementation of these phases of teaching were to facilitate the 4 four conditions for conceptual change to occur as had been proposed by Posner (1982), including dissatisfaction, intelligibility, plausibility, and fruitfulness. In the elicitation of students' preconceptions, questions were introduced through concepts cartoon to elicit students' preconceptions. The common misconception were then provided along with the explanation on why those misconceptions are incorrect, which aimed to make students realize the need to improve their knowledge regarding targeted concept. In the subsequent phase of teaching, various teaching media were utilized to facilitate the intelligibility and plausibility of targeted concepts. Power-point and video animation were deployed in the presentation of targeted concepts to help students comprehend the new concepts and view the concepts as possible candidate for resolving the problems offered. After facilitating the intelligibility and plausibility of the concepts, researcher then tried to facilitate the fruitfulness of targeted concepts by providing the activities which enable students to practice their understanding as well as to relate the concepts of NOS with the concepts of cellular respiration. In the last phase of teaching, reflection phase was conducted to provide the opportunity for students to review the concepts they have learned.

The implementation of conceptual change approach in this study has been effective in improving students' views of NOS as shown by the result of Nature of Science Questionnaire (NOSQ) post intervention which showed improvement in all targeted NOS aspects. Among all targeted NOS aspects, tentative nature of science showed major improvement, followed by creative nature of science. Before the teaching intervention, majority of students (93%) viewed that scientific knowledge can't change because scientists had taken a long time to explain the scientific knowledge. After the teaching intervention, all students (100%) realized the possibility of change in scientific knowledge, in which 87% of students recognized the possibilities of changes when new knowledge is obtained, and 13% of students recognized the possibilities of changes when new data is obtained or when old data is interpreted in different way. After the teaching intervention, 93 % of students recognized the importance of creativity in the development of scientific knowledge. There was only 7% of students who retained the view that creativity should not be used in the development of scientific knowledge.

The effectiveness of the teaching intervention in improving students understanding regarding tentative nature of science as well as the use of creativity in science may relate to the implementation of the activities which facilitates the accommodation of the new conceptions on students' cognition. One of the activities is the Hole Picture Activity which had provided students with opportunity to grasp the concepts of how scientific knowledge may change during its development as well as the role of creativity to develop scientific knowledge. During the activity, students worked in group to find out the shape of colored-paper inside the board through several small holes on the board's surface. The students first drew the shape of colored paper based on the clue they got from the holes provided. After showing the shape they drew, students were given the opportunity to add more holes on their board. Thus, they gain more clues on the shape of the colored paper inside and reshape their proposed shape of the colored paper inside. Students then discussed with their peers on how their activity may relate to the NOS aspects which had been

explained earlier. The activity was not only potential in showing the shortcoming of students' preconceptions regarding tentativeness of scientific knowledge, it also provided a simplistic example of how the knowledge gained through the observation can change when new data is obtained. Through the discussion with their group member to find out the example of changes during the development of knowledge about cellular respiration, a social learning environment was created for students to support the process of knowledge restructuring. The social learning environment involves social negotiation between teacher and students and also negotiation among students to confront their preconceptions and accommodating the new scientific conceptions.

The analysis of students' responses on CRQ post intervention also showed that students' cellular respiration conceptions had been enhanced, in which the highest improvement is regarding aerobic respiration concepts, particularly about the function of electron transport chain and ATP production. The learning activities conducted may have assisted the students to grasp the concept of electron transport chain despite its abstract nature which may cause major difficulty for students to comprehend the concept. Besides the use of animation in the presentation of targeted concepts, students were provided with the opportunity to show their ability to explain the electron transport chain by using a 3-Dimension model of electron transport chain. The use of modelling have been suggested as being powerful to foster conceptual change (David, 2005; Wu *et al.*, 2000), particularly for the process of cellular respiration which occurs in cellular level. The use of 3-dimension model of electron transport chain had been beneficial in helping students to comprehend the process of electron transport as they could move the electron directly while explaining how the process occur.

Despite the improvement of students' conceptions on aerobic respiration, many students retain their common misconception regarding the relation of breathing and respiration. The result of CRQ post intervention showed that 20 % were categorized in sound understanding category and 47% students were categorized in partial understanding. Although it is an improvement compared to prior teaching intervention, there were 33% of students who retain their misconceptions regarding the relation of breathing and respiration as they viewed that the term respiration means the same process as breathing. Despite had been provided with the explanations on the relation of breathing and respiration through discussion and the power-point as well as the worksheet, these students hold the conceptions that respiration and breathing is the same process. It may due to the resistance of students' conceptions regarding the concepts which had been constructed for years. Students had been familiar with the use of the term respiration which refer to the process of breathing. One of the student provided justification that respiration has the same meaning as breathing as it is what the students always learned since the early grade of primary school. This in turn support the assertion of many scholars that many misconceptions are resistant to change despite formal teaching (Duit, 2009; Duit and Widodo, 2008; Cakir and Yuruk, 2002).

## CONCLUSION

This study advocated that the teaching which aimed to promote students' NOS views as well as cellular respiration conception should consists of 5 phases of teaching, namely eliciting preconceptions, presenting common misconception, presenting targeted concepts, raising the status of targeted concepts, and reflecting on targeted concepts. The teaching necessarily gives equal attention to both NOS views and cellular respiration concepts, particularly the activities to raise the status of targeted concepts.

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