# An Initial Study on the Influences of Problem Solving in Children's Learning

Chwee Beng LEE[a], Ching Sing CHAI[b], Timothy TEO[c]
[a,b,c]*Nanyang Technological University, National Institute of Education, Singapore*
chweebeng.lee@nie.edu.sg

**Abstract:** Researchers have advocated problem solving to induce learners in conceptual change process as problem representation is central to whether or not learners achieve the intended change [1]. One way to help learners develop their problem representations is through tools that will enable them to externalize problem representations [2] and this can be done by encouraging learners to build dynamic models of the real world systems as it not only supports problem solving but also the transfer of knowledge. This study which included a sample size of 70 fifth grade students was conducted in a public elementary school in two science classrooms. Students who received the treatment were given an ill-structured problem to solve by building dynamic system models as a form of external representation. Quantitative data were collected through a pre and post test quasi experimental design. Responses from Knowledge Tests and Problem Solving Skills Tests were pilot tested for reliability prior to the actual study. Results gained from the pre and post tests showed that students who had gone through the problem solving activity achieved better conceptual understanding on the two main concepts of the water cycle-evaporation and condensation than those who were not given the treatment. This group of students also managed to build more sophisticated conceptual models. This suggest that a problem solving environment may enable students to develop or activate their problem solving skills and enabled them to see the value of meaning making in science.

**Keywords:** Problem Solving, conceptual change, dynamic system models

## 1. Introduction

Understanding chemical concepts has proved to be difficult for most students as most of the chemical concepts cannot be taught merely by showing an example [3, 4, 5] or verbal explanations. Traditional research on conceptual change has suggested that when learners are aware of the conflict between existing knowledge and scientifically proven information, conceptual change is probable [6]. On the contrary, many studies have shown that using cognitive conflict strategy [7] to foster conceptual change is insufficient to induce the change needed [8]. Hence, some researchers have advocated problem solving to induce learners in conceptual change process as problem representation is central to the change process [1]. One way to help learners develop their problem representations is through tools that will enable them to externalize problem representations [2] and this can be done by encouraging learners to build dynamic models of the real world systems as it not only supports problem solving but also the transfer of knowledge.

Current studies have revealed that when learners are aware of the conflict between existing knowledge and the scientifically proven information, conceptual change is most probable to happen [6]. Hence, this study proposes immersing learners in a problem solving environment [1, 9] in order to create cognitive conflict which will lead them to conceptual change.

In this study students were challenged to construct their own problem representations using a system modeling software (see figure 1). We argued that one way to help learners develop their problem representations is through tools that would enable them to externalize problem representations [2] and this could be done by encouraging learners to build models of the real world systems. The purpose of our recent study was to investigate the possible impact of problem solving on conceptual change. Specifically, it aimed to understand how problem solving influenced conceptual change in a fifth grade science lesson on the water cycle.

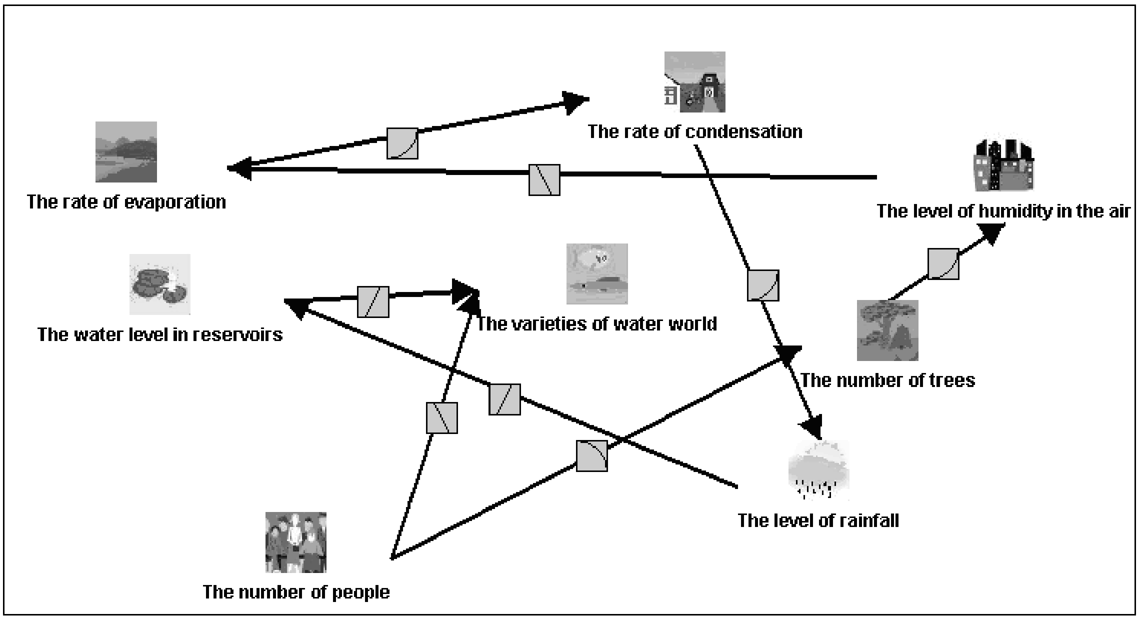


**Figure 1: A system model created using Model-It**

## 2. Theoretical Framework

### *2.1 Problem Solving in Conceptual Change*

Studies have shown that students bring into the classroom their daily life experiences about science phenomena which are typically incongruent with scientifically accepted concepts [3]. Unfortunately, such naïve conceptual models are relatively robust and difficult to remove [10, 11, 12, 13, 14] as they are rooted in the everyday life experiences and are supported by such experiences as a coherent explanatory structure [10, 15]. Hence, brining about conceptual change in learning in order to improve understanding is crucial. According to Vosniadou [16], conceptual change is a gradual process as learners first seek to integrate the new information from science instruction with their initial explanatory framework, creating what is called a "synthetic model" that lacks consistency. The next step would be to resolve such internal inconsistencies. To engage learners in conceptual change when learning science is through engaging learners in learning situation that will challenge and reorganize their existing naïve knowledge structure. Sinatra and Pintrich [6] further explained that in order to resolve this perturbation, one must engage in a series of experimentation, questioning, discussion or other types of high engagement [17] that will allow one to compare rival conceptions. In a longitudinal study of concept development, Novak [18] and colleagues have shown that while students who are committed to meaningful learning made tremendous improvement in learning whereas students who simply memorized knowledge and recalled in bits and pieces without forming a well-organized conceptual framework.

In our recent study, we argued that the problem solving as a meaningful and challenging activity provides students the opportunity to externalize their mental model, representing their cognitive understanding dynamically and perhaps enabling conceptual change [19]. Solving ill-structured problems often perturbs learners' conceptions, creating awareness of inconsistencies in their initial conceptual frameworks and those that are scientifically accepted [20].

### *2.2 Model Building for Problem Representation*

Our students were required to solve an ill-structured problem. Because ill-structured problems usually have divergent or alternative solutions, problem solvers need to construct multiple problem representations, for providing evidence for the development of an argument [21, 22]. The problem solver must then decide which of the problem spaces is closely relevant and useful for problem solving [22]. Most researchers conducting research in problem solving emphasize the importance of finding a relevant and efficient way to represent the problem as an initial effort in working toward a solution [1, 23, 24]. Studies have shown that experts are better problem solvers because they construct a richer, more coherent and well integrated mental representation than novices [25]. In this study, students constructed a system model as a form of problem representation that helped them to understand the phenomenon. A system model is a "conceptual, conjectural representation of the dynamic relations among factors in a system, resulting in a simulation that imitates the conditions and actions of it" [1] (p. 375). By using sets of building block icons, the students externalized their understanding of the given problem by constructing and testing their system models. Such a modeling process enabled students to consider the dynamic nature of ill-structured problem.

## 3. Methods

This study was conducted in early 2006. Statistical data were collected through a pre and post test quasi experimental design. The sample included 70 5th-grade students from a single public elementary school. Analysis were drawn mainly from the pre and post Knowledge Test, pre and post Problem Solving Skills Test, and students' problem representations. These instruments were tested for their reliability and validity in the pilot study. Students who received the treatment build their problem representations using a system dynamic modeling tool. Pre and post Knowledge Test were given to both groups of students. The 14-item pre and post Knowledge Test was crafted to measure four levels of cognitive processes-understanding, evaluation, analyzing, and application on students' conceptual understanding of the two main concepts of the water cycle-evaporation and condensation. A total score was awarded for the multiple choice section and students' rationales were categorized into "Synthetic model," "Scientific model," "Initial model,", "Textbook model," or "No Sense model." Students who received the treatment also received a pre and post Problem Solving Skills Test whereby they were requested to solve an ill-structured question on the water cycle. Students' problem representations (system models) were assessed using a rubric carefully crafted based on experts' comments and they were coded by two independent raters.

## 4. Findings

Results showed that students who had gone through the problem solving activity achieved better conceptual understanding on the two main concepts of the water cycle-evaporation and condensation than those who were not given the treatment. Also, it was found that not only was problem solving skills significantly and positively correlated with students' conceptual knowledge, they were also a predictor of conceptual knowledge. This suggested that as students' problem solving skills improved their conceptual understanding on the concepts of the water cycle also improved. Results also showed that students who experienced problem solving had replaced their lower order conceptual model with conceptual models of higher order ranking such as "Textbook" and "Synthetic" models. In contrast, the total number of lower order conceptual models for the group who did not receive the treatment increased while all other categories of conceptual models experienced a fall. This might indicate the value of immersing students in a problem solving environment as it gave them opportunities to make conscientious efforts to detect their conceptual deficits and reconcile their understanding, bringing themselves to a higher level of cognition. The statement mirrors the findings presented by Vosniadou and Brewer [26] when the researchers found that elementary school children could provide accurate explanations of the day-night cycle.

Interestingly, results obtained from the group that did not receive any treatment suggested that there could be that there was a downward shift of understanding, meaning that some of the "Initial" conceptual models could have moved to "No Sense" models which are more inferior conceptual models. This phenomenon seemed to justify DiSesssa's view [27] that intuitive physics was based on superficial and fragmented interpretations of physical reality. If this was true, then it was probably justifiable to suggest that the treatment received by students helped them to re-structure their fragmented understanding into understanding that was more stabilized; otherwise, they would have the same experience as those who did not receive the treatment.

## 5. Conclusion

As one of the first studies that used the dynamic modeling tool as a platform for problem representation with elementary school children, this study may offer some insight and add value to future research that intend to follow this direction. The findings of this study have revoked claim that young children are unable to engage in sophisticated level of cognitive thinking as a result of limited experiences. The findings of this study suggest that a problem solving environment may enable students to develop or activate their problem solving skills and enabled them to see the value of meaning making in science, and to be actively involved in the process of learning science. Despite encouraging findings, the authors would like to caution readers that as a result of small numbers of participants, the results cannot be generalized beyond this study. More robust research is needed in order to further substantiate the conclusions.

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