# INVESTIGATION OF THE EFFECTIVENESS OF THE USE OF AN ADVANCED CONCEPT MAP IN THE REVISION OF PREVIOUSLY TAUGHT CONTENT

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**Abstract**. In lessons to revise previously taught science content in junior high school, students were shown an advanced concept map drawn by a subject-matter expert (referred to as an "adult concept map" in this study) and asked to compare it with their own concept maps. Investigation into the effectiveness of revising previous content using an "adult concept map" confirmed, with a 5% risk rate, a significant increase in "more advanced scientific concepts." Results showed that, when revising previously taught content, an "adult concept map" is an effective teaching resource for an improved understanding of igneous rock and minerals.

## 1 Introduction

Recently in Japan, the concept map (Novak & Gowin, 1984) has been actively used in schools and researchers have progressed in understanding its use. Furthermore, the concept map has gained attention, not only as a method of finding out about the concept that each student holds (that is the level of their understanding of nature and natural phenomena), but also as a tool to encourage collaborative learning and concept construction by students. For example, researchers concluded that using a concept map in lessons promotes concept construction by students. Moreover, there has been research into whether collaborative learning is supported by the joint production of a concept map by a number of students, or the comparison of one's own concept map with those of other students. For example, Taga et al. (2007) investigated the use of a concept map drawn by an older student with a good grasp of the topic and found that a concept map created by a learner with whom the students can identify was an effective strategy. In the lessons in this study, an "adult concept map" was used, rather than an older student's concept map, to verify whether or not it is effective when revising previously taught content.

## 2 Research Aim

The aim was to investigate the effectiveness of an "adult concept map" in revision lessons, by clarifying its impact on learning previously taught content.

## 3 Research Method

### *3.1 Method of Implementation*

The students had already been taught about igneous rock and minerals in their science curriculum in the first year of junior high school. To revise this content, a lesson was delivered in March at the end of the second year of junior high school using an "adult concept map." In this lesson, the students were placed in groups of four and instructed to explain their previously drawn individual concept maps to each other and engage in discussion about them, though concept maps they used are not Novakian. Then they compared their own individual concept map with an "adult concept map" which was produced by a high school geology teacher who had taught about igneous rock and minerals for many years (Fig. 1).

### *3.2 Research Subjects and Content of Lesson*

The research subjects were second year students (21 students) at a junior high school in Shiga Prefecture, Japan. In their first year, they had been taught about the types of igneous rock produced from magma as well as the types of rock-forming minerals that make up igneous rock, while observing volcanic ash.

### *3.3 Implementation Procedure*

The implementation procedure is shown in A-D below. The lesson was an hour long (50-minute instruction time).

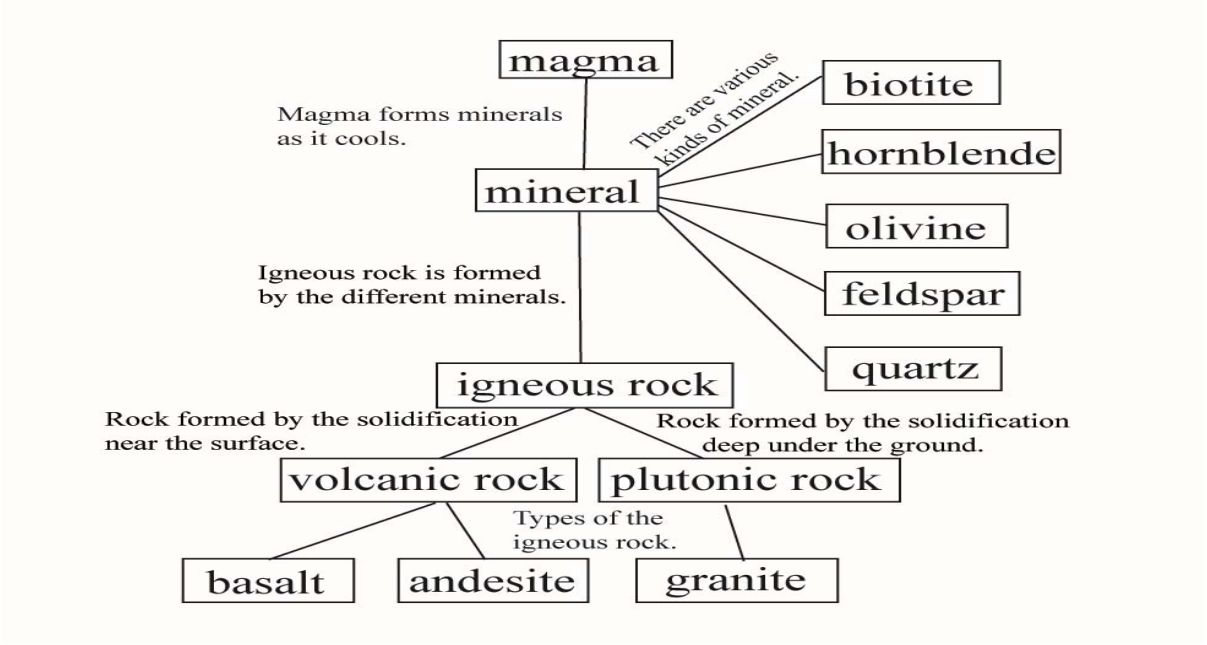


**Figure 1**. Advanced concept map by an expert adult.

### 3.3.1 Previous Lesson

In the lesson prior to the lesson in question, the students worked collaboratively in groups of four while sticking text book photos of rocks and minerals onto a big sheet of paper and drawing lines to represent the relationships between the photos. Thereafter, each team gave a three-minute presentation on their design. Students who had not drawn a concept map before were then taught to draw one. Then each student was asked to draw a concept map (the "before" concept map) regarding "igneous rocks and minerals," which is the title of the unit studied in their first year. Nine concept labels were available for use, namely "andesite," "quartz," "hornblende," "granite," "magma," "biotite," "feldspar," "minerals," and "igneous rock." These were chosen from among the vocabulary taught in the first year igneous rock and rock-forming minerals unit.

### 3.3.2 The Lesson

A. In groups of four, one by one, the pupils each show and explain the concept map they produced in the previous lesson. Each pupil then fills in a worksheet concerning the differences between their own concept map and those created by other students.
B. The teacher gives out the "adult concept map," explaining that it is a concept map drawn by an expert adult and asks each student to compare it to the concept map that they drew themselves. Working alone, each pupil considers points of difference and other noteworthy things and fills in a worksheet.
C. Each pupil draws another concept map (the "after" concept map). The concept labels available for use are the same as before.
D. At the end of the lesson, the pupils write down their views with regard to the lesson.

### *3.4 Method of Investigation of the "Adult Concept Map"*

In order to ascertain whether changes in the pupils' concept were attributable to instruction using an "adult concept map," the "before" and "after" concept maps drawn by the pupils were compared. As an investigation method, in line with Taga et al. (2007), a statistical review was carried out into whether the pupils' concept maps showed a significant increase in understanding the links between words as seen in the "adult concept map."

## 4 Results of the Implementation

Typical concept map examples are shown (Fig. 2), and there is a numerical demonstration of significant change in the concept visible in the concept maps.

### *4.1 Pupils' Concept Maps*

Figure 2 shows a pupil's concept map before the lesson and after the lesson. The concept map drawn after the lesson is more complicated, includes minerals, and shows a deeper understanding regarding the relationship between minerals and igneous rock. The pupil now knows that "magma forms minerals as it cools" and that "igneous rock is formed by the different minerals." Also, the absence of minerals in the "before" concept map implies that the pupil's understanding of minerals was insufficient. However, in the "after" concept map, the pupil mentioned various types of minerals as well as the relationship between igneous rock and magma.

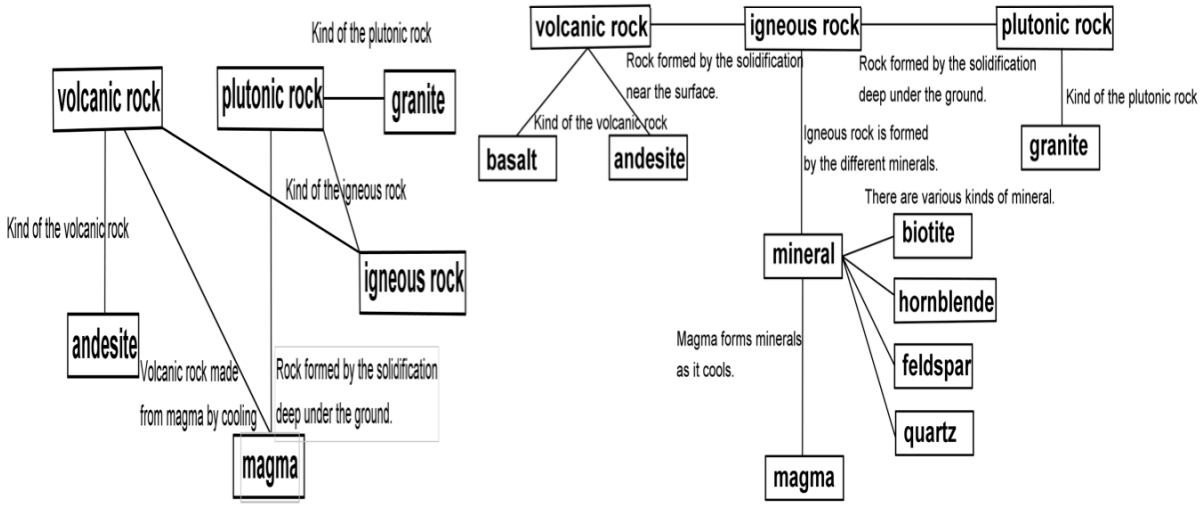


**Figure 2**. A pupil's concept maps (left produced before the lesson, right after).

### *4.2 Analysis Results*

On the "before" and "after" concept maps, the number of "magma – mineral" links (showing that the pupil knows that "magma forms minerals as it cools") and "mineral – rock" links (showing that the pupils knows that "igneous rock is formed by the different minerals") were counted. Whether the number of incidences had changed significantly was calculated using Fisher's exact probability test (two-sided test). The 2x2 cross tables in Table 1 show the numbers depicting the magnitude of the increase and decrease.

N = 21.

| "magma – mineral" Magma forms minerals as it cools | Number of links obtained | Number of links not obtained |
|---|---|---|
| Concept Map [before] | 1 | 20 |
| Concept Map [after] | 19 | 2 |

| "mineral – rock" Igneous rock is formed by the different minerals | Number of links obtained | Number of links not obtained |
|---|---|---|
| Concept Map [before] | 2 | 19 |
| Concept Map [after] | 19 | 2 |

**Table 1:** 2x2 cross tables.

The "magma – mineral" link cross table shows a significant increase in understanding that "magma forms minerals as it cools," with a 5% risk rate ($p=0.0000$, $p<.05$). In addition, the "mineral – rock" link cross table shows a significant increase in understanding that "igneous rock is formed by the different minerals," also with a 5% risk rate ($p=0.0000$, $p<.05$).

## 5 Discussion

### *5.1 Review of the Concept Map Analysis Results*

Although they had already been taught about igneous rock and minerals in their first year, few students included the concepts that "magma forms minerals as it cools" (which shows the link between magma and minerals) and that "igneous rock is formed by the different minerals" (which shows the link between minerals and rock) in the concept map they drew prior to the lesson in this study. The existence of these two links leads to the understanding that "minerals crystalize from magma and combine to form igneous rock" and deepens comprehension. In the lesson for this study, each pupil compared their own "before" concept map with the "adult concept map," resulting

in a significant increase in the inclusion of each of these links. As a result, students achieved a deeper level of understanding than before the lesson.

### *5.2 Review of Worksheet Comments*

Some of the comments on the worksheets in which pupils compared their map with other people's included: "My concept map was harder to read than other people's; I think that it is OK that some people have written a lot on their concept maps and some people's maps are very easy to read," and "Everyone's was very easy to understand." The pupils were able to look back over their own concept maps objectively by comparing them to concept maps created by other people.

Some of the comments on the worksheets in which students contrasted their map with the "adult concept map." included: "It summarized things in a simple way that is very easy to understand. I thought it would be more difficult with lots of writing, but it was incredibly simple. It was easy to understand." Since the students had already produced their own concept map and compared its features in a group setting, the pupils easily understood the features of the "adult concept map." It is conceivable that, because they had practical experience comparing their concept maps with others, comparing their own concept map with the "adult concept map" led to deeper understanding.

In the final feedback, there were many comments along the lines of: "In this lesson, I was able to recall things that I didn't really understand before and things that I had forgotten and I was able to understand more about volcanoes," and "I think that depicting the relationship between igneous rock and minerals with a link between the words was very powerful. I think that the process of investigating, thinking, and summarizing briefly oneself makes things easy to remember and is effective. In addition, in the final team exchange of views, I was impressed by how other people thought and summarized things. I would like more opportunities of this kind." Students also stated, "By writing a concept map, I got to understand things that I didn't understand before and it was good to learn about things like making concept maps," and "The 'adult concept map' by someone who understood things well was easy to understand and straightforward, and there were many things that I could copy in future."

Pupils who experienced the group activity revised and reconstructed their own understanding of the content by referring to the "adult concept map." In this study, the method of using a concept map in revision lessons was devised, and the aforementioned feedback also made it clear that the "adult concept map" used in this lesson was effective in revision.

## 6 Summary

In this study, the effectiveness of an "adult concept map" in science revision lessons at junior high school was investigated. The science curriculum content in question related to igneous rock and minerals and involved the revision of previously taught content. In order to deepen understanding of the curriculum content, an "adult concept map" was utilized. As a result, the class using the "adult concept map" significantly deepened their understanding of the definition of igneous rock and minerals and the difference between the two. This made it clear that using an "adult concept map" when middle school students revise previously taught content is effective. Looking ahead, I would like to find out whether the "adult concept map" is also effective with children of other ages.

## 7 Acknowledgements

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## References

Novak, J. D., & Gowin, D. B. (1984). Learning How to Learn. New York: Cambridge University Press.

Taga, M., Nishikawa, J., Kubota, Y., & Kusachi, I. (2007). Development and Evaluation of Teaching Materials for Understanding Crystallization Differentiation. Journal of Research in Science Education, 47(3), 15-22 (in Japanese).