한국과학교육학회지, 27권 2호, pp. 120-125(2007. 03) J Korea Assoc. Res. Sci. Edu, Vol. 27, No. 2, pp. 120-125(2007. 03)

A Test of the Confirming Abduction Model: How Do Students Confirm Their Hypotheses During the Process of Scientific Hypothesis-Generation?

Jin-Su Jeong* · **Yong-Ju Kwon**

Korea National University of Education

Abstract: The purpose of the present study was to test the validity of the confirming abduction model (CAM). CAM is a process model which explains how reasoners confirm their hypothetical explicans. To test this model, 154 8th grade students were sampled from one middle school in Korea. Three types of vapor condensation hypothesis confirming tests were developed and administered to the subjects. The results of this study revealed that student confidence increased when hypothetical explicans were borrowed into experienced phenomena from questioning phenomena. These results validated CAM. According to CAM, the process of confirming hypothetical explican is as follows: representing a questioning phenomenon, representing an experienced phenomenon that is similar to the questioning phenomenon, representing the hypothetical explican of the questioning phenomenon, comparing the questioning phenomenon with the experienced phenomenon, and borrowing the hypothetical explican as the hypothetical explican of the experienced phenomenon from the hypothetical explican of the questioning phenomenon. This study also discussed the implications of these findings for teaching and learning in science education.

Key words: hypothesis, confirming abduction model, hypothetical explican, questioning phenomenon, experienced phenomenon

I. Introduction

Hypothesis generation has been regarded as one of the core reasoning processes in creative thinking and scientific discovery (Klahr & Simon, 1999; Kwon *et al.*, 2000; Lawson, 1995; McPherson, 2001). A hypothesis is a proposition proposed as a tentative causal explanation for an observed phenomenon (Atkins, 1989; Darian, 1995; Enger & Ross, 2003; Kimball, 1994; Lawson, 1995; Slabaugh & Parsons, 1976; Uno & Moore, 2001).

Many eminent philosophers denied the existence of logical or cognitive processes for scientific hypothesis-generation (Darden, 1991; Petty, 2001). Popper (1968), for instance, said that, "the initial stage, the act of conceiving or inventing a theory, seems to me neither to call for logical analysis nor to be susceptible to it." Hanson (1958), however, asserted that, "the initial suggestion of a hypothesis is very often a reasonable affair. It is not so often affected by intuition, insight, or other imponderables as biographers or scientists suggest." He claimed that reasoning in discovery required a different logic from either deduction or induction. Peirce also asserted that the function of abduction is the process of generating an explanatory hypothesis and that the abduction is the only logical operation which introduces any new hypothesis (Fischer, 2001).

Actually, the type of inference called abduction was firstly studied by Aristotelian syllogistics (Fischer, 2001). Aristotle dealt with deduction and induction but did not analyze abduction in detail; abduction, therefore, remained absent from the history of logic until it was rediscovered by Peirce (Magnani, 1997). Peirce spent four decades on the investigation of induction and deduction, models of thinking well established in logic and the philosophy of science, and supplemented them with an inferential procedure which he called abduction (Fischer, 2001).

Hanson (1958) also claimed that reasoning in

*Corresponding author: Jin-Su Jeong (jinsu@hwp.or.kr)
**Received on 28 April 2006, Accepted on 11 December 2006

discovery required a different kind of logic from either deduction or induction. He called this logic "abduction" or "retroduction": It is the process of inferring an explanation for an observation. He distinguished three kinds of inference: deduction, induction, and abduction. For Hanson abduction is the inference that is from surprising data that is explicanda to explanation that is explicans. Hanson gave tantalizing hints about reasoning in discovery, especially he suggested that puzzling facts provide a beginning point for hypothesis generation and analogies might play a role in hypothesis generation, but he did not develop methods for using analogies in hypothesis generation (Darden, 1991).

The notion that analogies play an important role in abduction for hypothesis generation was also emphasized by several studies (Jeong & Kwon, 2001; Kwon *et al.*, 2000; Lawson, 1995, 2000; Moore & Vodopich, 1998). Lawson (1995) claimed that abduction requires some guessing about causes, the guessing coming not from induction or deduction, but from prior knowledge and the creative process of abduction. In Lawson's view, abduction involves sensing ways in which the current situation is somehow similar to other known situations and then using this similarity as a source of hypotheses in the present situation.

Moreover, Jeong & Kwon (2001) and Kwon *et al.* (2000) claimed that hypothesis generation starts with identifying a current causal question and a previously experienced world which may have a strong qualitative likeness with the current question world. Second, a scientific reasoner represents an explanation of the previously experienced world. Third, the reasoner uses the explanation as a hypothesis for the current question world.

Jeong (2004) developed the triple abduction model (TAM), which is the process model of scientific hypothesis generation. TAM shows that a scientific hypothesis is generated through three stages, such as the stage of analyzing question, the stage of searching explicans, and the stage of constructing hypothesis. TAM also contains the observing, hypothesizing, and confirming abduction models. In TAM, the confirming abduction model (CAM) explains how a reasoner confirms the hypothetical explican (Fig. 1).

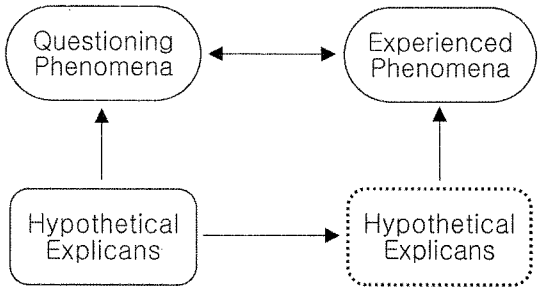

Fig. 1 *The Confirming Abduction Model (Jeong, 2004)*

According to CAM, the process of confirming hypothetical explican is as follows: (1) representing a questioning phenomenon, (2) representing an experienced phenomenon that is similar to the questioning phenomenon, (3) representing a hypothetical explican of the questioning phenomenon, (4) comparing the questioning phenomenon with the experienced phenomenon, and (5) borrowing the hypothetical explican as a hypothetical explican of experienced phenomenon from the hypothetical expelican of the questioning phenomenon. CAM asserts that the reasoner's confidence is increased when a hypothetical explican is borrowed into an experienced phenomenon from a questioning phenomenon. This assertion is in accordance with the opinions of the Bonfantini and Proni's study (1988).

The purpose of the present study was to test the validity of CAM, which is the process model of confirming hypothesis explicans. The model was tested by the hypothetico-deductive approach.

II. Methods and Procedure

1. Subjects

Subjects were 154 8th grade students sampled from one middle school in Korea. The subjects ranged in age from 13.21 to 14.71 years with a mean age of 14.26 years (SD = 0.36).

2. Instruments

The vapor condensation hypothesis confirming tests (VCHCTs) were developed to test CAM. The VCHCTs were open response type paper and pencil tests. Three types of VCHCT were developed.

Type A involves the relationship vapor condensation and the presented situation of morning dew. Each

subject was asked to identify the cause of the phenomenon and explain how she/he convinced herself/himself of her/his hypothesis. *Type A* is as follows:

> *Generating hypothesis I.* You can see morning dew formed on a leaf on an autumn morning. Why does morning dew form? Explain in detail the formation of the morning dew.
>
> *Question 1.* In your opinion, how accurate is your answer for the above generating hypothesis Ⅰ? Choose and encircle one number below.
>
> 1. Very accurate
> 2. Somewhat accurate
> 3. Just normal
> 4. Somewhat inaccurate
> 5. Very inaccurate

Type B involves the relationship between vapor condensation and the presented situation of water formation on inner side of the bus window. Each subject was asked to identify the cause of the phenomenon and to explain how she/he had convinced herself/himself of her/his hypothesis. Each subject was again asked to identify how she/he had convinced herself/himself of the above hypothesis Ⅰ which is the causal explanation of the existence of the morning dew.

Type C involves the relationship between vapor condensation and the presented situation of water formation on the outer side of the cup containing ice water. Each subject was asked to identify the cause of the phenomenon and to identify how she/he had convinced herself/himself of the hypothesis. The subjects were again asked to identify how she/he had convinced herself/himself of the above hypothesis Ⅰ which is the causal explanation of the morning dew.

The content validities of these tests were investigated. To obtain a measure of the face validity of the test, nine professors with relevant expertise and eight graduate students majoring in science education were asked the question, "Do you agree that the tests can assess the degree of subject confidence in the hypothesis?" The average validity was 0.92.

3. Test Procedure

The test procedure was divided into three steps. In the first step, *type A* was administered to identify the morning dew phenomenon hypothesis and to assess the degree of subject confidence in hypothesis Ⅰ. In the second step, *type B* was administered to identify the water formation on a window phenomenon hypothesis and to assess the degree of subject confidence in hypothesis Ⅰ. In the final step, *type C* was administered to identify the water formation on a cup phenomenon hypothesis and to assess the degree of subject confidence in hypothesis I.

4. Study Prediction

According to CAM, subject confidence in a self-generated hypothesis depends on representing a experienced phenomenon which can be causally explained by the hypothetical explican of the questioning phenomenon.

Therefore, the confidence scores of subjects who generate the same hypotheses on the three tests were predicted to increase through steps 1 to 3; however, the confidence scores of subjects who generate different hypotheses on the three tests were predicted to decrease through steps 1 to 3.

Ⅲ. Results and Discussion

The confidence scores of subjects who generated the same hypotheses (an example is shown in Fig. 2) on the three tests increased through steps 1 to 3; however, the confidence scores of subjects who generated different hypotheses (an example is shown in Fig. 3) on the three tests decreased through steps 1 to 3.

Table 1 shows that the mean scores of confidence vary from 3.00 (Group Ⅱ, Step 3) to 3.77 (Group Ⅰ, Step 3). To determine which differences among the mean scores of the steps were statistically significant, the Repeated Measures Test was conducted in each group.

In *Group Ⅰ*, the Repeated Measures Test by step showed that the difference among the steps was statistically significant ($F_{2,137} = 10.177$, $p < 0.01$). In *Group Ⅱ*, the Repeated Measures Test by step showed that the difference among the steps was also statistically significant ($F_{2,17} = 8.129$, $p < 0.01$). These results are graphed in Fig. 4.

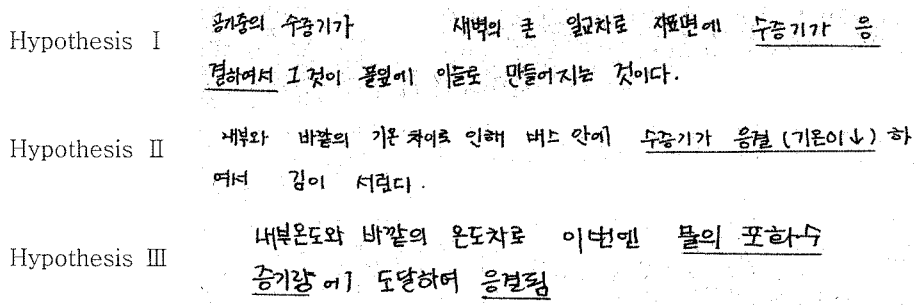

Fig. 2 *An example of same hypotheses*

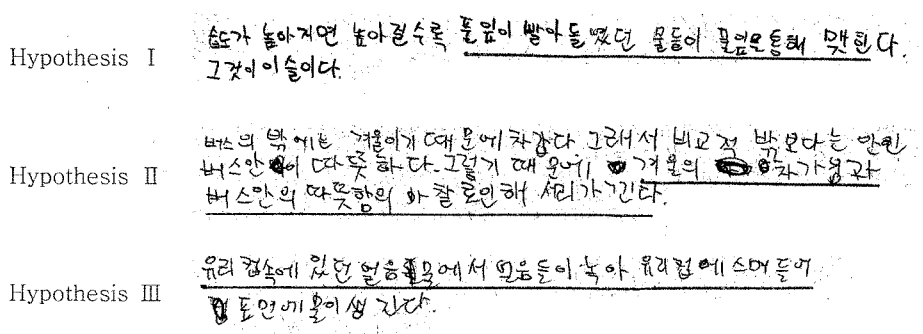

Fig. 3 *An example of different hypotheses*

Table 1

Mean scores of confidence in the hypothesis and the result of repeated measures test

Group	Step 1	Step 2	Step 3	F
I (N = 137)	3.61	3.67	3.77	10.177*
II (N = 17)	3.50	3.17	3.00	8.129*
Total (N = 154)				

Note. N = Number of subjects, $^{*}p < 0.01$.

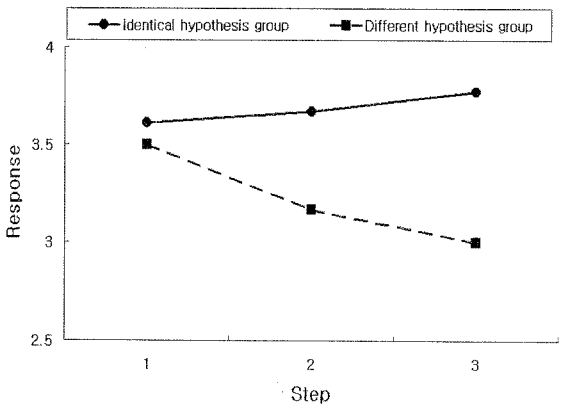

Fig. 4 *The mean scores of confidence on the Vapor Condensation Hypothesis Confirming Tests by group*

These results fit well with the prediction that the confidence scores of subjects who generated the same hypotheses (vapor condensation) on the three tests would increase through steps 1 to 3, whereas the confidence scores of subjects who generated different hypotheses on the three tests would decrease through steps 1 to 3. In fact, 85% subjects among subjects answered that their degree of confidence changed because the phenomenon generating hypothesis 1, 2, and 3 were similar.

The results of this study are in agreement with a study on abductive reasoning (Bonfantini & Proni, 1988). Bonfantini & Proni studied a "Sherlock Holmes" novel by Sir Arthur Conan Doyle to analyse the structure of the investigation. In the novel used for the study, Holmes observed that the lips of the corpse of a victim had a slightly sour smell (questioning phenomenon). This observation might lead one to suppose that the victim had been poisoned (hypothetical explanation). Some similar cases (experienced phenomenon) made this (hypothetical explanation) plausible (confidence). This confirming process was fitted with the process of the confirming abduction model. Several research papers on hypothesis generation suggest that people might act as satisfiers and be less likely to generate

plausible alternative hypotheses (Garst *et al.*, 2002).

According to Adsit & London (1997), reasoners prefer to confirm any hypothesis on which they may be working. Reasoners make hypothesis testing errors because they focus on confirming their ideas rather than on looking for other ideas to test. Why do they make these testing errors? The results of the test of the conforming abduction model may reveal a cause. Presumably, the reasoners' firm confidence prevents them from considering alternative hypotheses.

IV. Conclusion and Implications

The results of this study revealed that the difference among the steps was statistically significant ($F_{2,137} = 10.177$, $p < 0.01$) in *Group I* and the difference among the steps was also statistically significant ($F_{2,17} = 8.129$, $p < 0.01$) in *Group II*. These results fit well with the prediction that the confidence scores of subjects who generated the same hypotheses on the three tests would increase through steps 1 to 3, whereas the confidence scores of subjects who generate different hypotheses on the three tests would decrease through steps 1 to 3.

These results validate CAM. According to CAM, the process of confirming hypothetical explican is as follows: representing a questioning phenomenon, representing an experienced phenomenon that is similar to the questioning phenomenon, representing a hypothetical explican of the questioning phenomenon, comparing the questioning phenomenon with the experienced phenomenon, and borrowing the hypothetical explican as a hypothetical explican of experienced phenomenon from the hypothetical explican of the questioning phenomenon.

The most important contribution of the present study involves the fact that the testing validated the process model for confirming hypothesis explican. This result holds implications for instructional designs to improve students' inquiry ability. For example, in inquiry learning, students frequently reject their hypotheses before testing them. In these cases, how can teachers help the students? The model validated in this study holds implications for assisting the students. For instance, after generating hypotheses, if students have the intention of abandoning these hypotheses, they are asked to represent similar experienced phenomena to questioning phenomena. If students can not represent similar phenomena, teachers can assist the students by giving similar phenomena. In this way, teachers can help students in obtaining confidence in their hypotheses.

References

Adsit, D. J., & London, M. (1997). Effects of hypothesis generation on hypothesis testing in rule -discovery tasks. The Journal of General Psychology, 124(1), 19-34.

Atkins, P. W. (1989). General chemistry. New York, NY: W. H. Freeman and Company.

Bonfantini, M. A., & Proni, G. (1988). To guess or not to guess? In U. Eco & T. A. Sebeok (Eds.), The sign of three: Dupin, Holmes, Peirce, pp. 119 -134. Bloomington, IN: Indiana University Press.

Darden, L. (1991). Theory change in science: Strategies from mendelian genetics. New York: Oxford University Press.

Darian, S. (1995). Hypotheses in introductory science texts. International Review of Applied Linguistics in Language Teaching, 33(2), 83-109.

Enger, E. D., & Ross, F. C. (2003). Concepts in biology, 10th ed. New York, NY: The McGraw-Hill Compaines, Inc.

Fischer, H. R. (2001). Abductive reasoning as a way of worldmaking. Foundation of Science, 6, 361 -383.

Garst, J., Kerr, N. L., Harris, S. E., & Sheppard, L. A. (2002). Satisficing in hypothesis generation. The American Journal of Psychology, 115(4), 475-480.

Hanson, N. R. (1958). Patterns of discovery: An inquiry into conceptual foundations of science. Cambridge, UK: Cambridge University Press.

Jeong, J. (2004). Development of the triple abduction model and its application to scientific hypothesis generation. Unpublished Doctoral Dissertation. Cheongwon, Chungbuk: Korea National University of Education.

Jeong, J., & Kwon, Y. (2001). Roles of abductive reasoning and prior knowledge in high school students' generating biological hypotheses. A paper presented at the 2001 NABT National Convention, Montreal, CA, November 10.

Kimball, J. W. (1994). Biology, 6th ed. Dubuque, IA: Wm. C. Brown Publishers.

Klahr, D., & Simon, H. A. (1999). Studies of scientific discovery: Complementary approaches and convergent findings. Psychological Bulletin, 125 (5), 524-543.

Kwon, Y., Yang, I., & Chung, W. (2000). An explorative analysis of hypothesis-generation by pre -service science teachers. Journal of Korean Association for Research in Science Education, 20, 29-42.

Lawson, A. E. (1995). Science teaching and the development of thinking. Belmont, CA: Wadsworth Publishing Company.

Lawson, A. E. (2000). How do humans acquire knowledge? and what does that imply about the nature of knowledge?. Science & Education, 9, 577-598.

Magnani, L. (1997). Basic science reasoning and clinical reasoning interwined: Epistemological analysis and consequences for medical education. Advances in Health Sciences Education, 2, 115-130.

McPherson, G. R. (2001). Teaching & learning the scientific method. The American Biology Teacher, 63(4), 242-245.

Moore, R., & Vodopich, D. S. (1998). Botany, 2rd ed. New York, NY: The McGraw-Hill, Inc.

Petty, M. E. (2001). A case study of the abductive reasoning processes or pre-service elementary education students in a role playing setting concerning a mock senate hearing on global climate change. Unpublished Doctoral Dissertation. Bloomington, IN: Indiana University.

Popper, K. (1968). The logic of Scientific Discovery. New York: Harper & Row, Publishers.

Slabaugh, W. H., & Parsons, T. D. (1976). General chemistry, 3rd ed. New York, NY: John Wiley & Sons, Inc.

Uno, G., Storey, R., & Moore, R. (2001). Principles of botany. New York, NY: The McGraw-Hill Compaines, Inc.