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The Effects of Implementing a Science History Program for Improving Students' Scientific Process Skills

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Abstract: This project was carried out under the assumption that applying a science history program to a teaching-learning process would lead to students' increased interest in science and increase the development of their scientific process skills. The project aimed at designing an effective science history program which would help to improve students' scientific process skills, to enhance their interest in learning science, and to maintain their inquiry learning abilities. The survey for the activity objectives was produced by the authors. The test items used for testing students' scientific attitude and scientific process skills were created by Korea National University of Education. The survey about scientific perception indicated that there was a meaningful difference of $p = 0.005$ before and after implementing this program. The survey about scientific interest shows that students became interested in science, science-learning and science-related activities after participating in the science history program. Students' scientific process skills increased by 9% after the program was implemented in the subjects' classes. This indicates that the science history program was effective in improving students' science scientific process skills. Since this project, which targeted 8th grade science education activities, has proven to be effective, developing other programs suitable for younger and older students seems promising, too.

Keywords: science history program, scientific process skills, scientific attitudes, scientific perception

Introduction

Scientific knowledge changes as new discoveries are made. Inquiry instruction focusing on scientific processes (Lederman & Zeidler, 1987; Edmonson, 1989; Aikenhead & Ryan, 1992) is emphasized in science learning of the current curriculum. In Korea, most students, however, feel that science is too hard to study, and science is very boring (Lee & An, 1999). Educators in Korea have been promoting the development of science education for the past decades, but these efforts have not given birth to any tangible results. This is confirmed by the fact that Korean students produce lower results as their grades go up, a survey released by the Secondary International Science Study (SISS). Therefore, science education must make drastic changes so that students will become interested in science, maximize the extension of scientific process skills and creative mind. A new way should be pursued which can bridge humans and science.

According to previous studies, there are several factors which play key roles in extending student's scientific process skills to their daily lives: the type of teaching-learning model (Lee & An, 1999), inculcation of the solution ability (Kim & Kang, 1998) and research atmosphere (Choi & Yoon, 2000).

There has been, however, no example that utilizes a science history program to enhance scientific process skills. It is meaningful to verify whether a science history program has effects on the scientific process skills.

The seventh national science curriculum states as one of its objectives to stimulate students' interest in and curiosity about science by introducing current science developments, scientist stories, and daily scientific content in science class. The high school science curriculum includes science history as an elective subject. The appearance of science history education in the seventh curriculum represents a change from the past when science history

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was absent (The Ministry of Education and Human Resources, 1997). Various scientific discoveries or concepts did not come into being in a day; rather they have been produced through trial and error by a great number of people over several thousand years. It will be more natural and appealing, then, to teach science in a developmental order the concepts in science history (Mattews, 1994) rather than just to depict it as scientific truth during concise lectures.

This research is based on the assumption that a science history program will help students to have a curiosity about science and to improve their scientific process skills (Solomon, 1992; Yang et al., 1996). So the authors dealt in this study with science history and background stories that lead to the development of great scientific concepts, ideas, and experiments.

The purpose of this study is to let students expand their scientific process skills by implementing a scientific program. The specific objectives of this study are as follows.

First, the authors sought to develop a science history program that would expand students' scientific process skills related to the subject matter. Second, we applied the science history program to a teaching-learning process to inspire students' interest in science class. Third, we sought to create conditions that would mobilize scientific activities in terms of the science history program.

In this study we raised the following research questions and tried to solve them.

First, how do we select the stories/episodes in science history that are relevant to the subject matter? Second, how do we design a science history program which will contribute to expanding students' scientific process skills? Third, how do we form the conditions in which the research activities are executed with the help of a science history program?

This paper restricts its research scope as follows. Due to the small number of subjects in the study (12 eigth students), It is hard to generalize clearly about the statistical data. Since the same questionnaire was used both in the pre- and post-test, the experience of the pre-test may have affected the result of the post-test.

Methodology

Preliminary Investigation for Clarifying Research Questions

The authors surveyed the general responses that eighth grade students showed regarding science from March 2, 2003 till March 10, 2003 in order to collect basic data for the study. The result is as follows in Table 1.

Most students responded that science is hard and uninteresting due to its theory-orientedness and teacher-orientedness. They do not ask questions because they do not have interest in science class. In addition, they do not prepare for the class. Therefore achievements in science class are poor when compared with those of other subjects. Students want the content to be easier and more interesting and they want science classes to include more student-oriented research activities.

To solve the present problems, teachers should spend more time making a more thorough preparation for the class and should put in more effort to develop various effective teaching material. We strongly believe application of a science history program to a teaching-learning process can at least partially solve the current problems.

A Design of Study

This study targeted eighth graders (N = 12, males: 4; females: 8) during 9 months from March 10 until November 30, 2003. It proceeded as follows:

- Selection of subjects, literature survey, and review of the previous analyses, completed by February in 2003.

- Preparation of basic investigation, analysis of the present situation, setting the performance goal and preparation of the project plan, completed by

Table 1. The Pre-test Results (N = 12, Unit: %) ① Strong affirmation, ② Affirmation, ③ Just so, ④ Refusal

Classification	Response			
Perception about inquiry instruction	① 16.7	② 16.7	③ 25.0	④ 41.7
Experience of inquiry instruction	① 0	② 16.7	③ 25.0	④ 58.3
Interest in science instruction	① 0	② 16.7	③ 58.3	④ 25.0
Question experience during the class	④ 41.7	③ 41.7	② 16.7	① 0
Experience about preparation	④ 58.3	③ 25.0	② 16.7	① 0
Achievement comparison with other subjects	④ 16.7	③ 41.7	② 33.3	① 8.3
Science-related reading experience	④ 33.3	③ 25.0	② 25.0	① 16.7
Requests in science class	fun 41.7	experiment 33.3	level 16.7	debate 8.3

Table 2. The subjects of activity

Physics	Galilei's inertia experiment, Law of motion (I. Newton), Discovery of electricity & magnetism, Kirchhoff's law, Ohm's law
Chemistry	Celsius & Fahrenheit's temperature scale, Discovery of Archimedes, Tswett's chromatography
Biology	Hooke' microscope, Knop's solution, Discovery of vitamin, Photosynthesis, Stimulus-response, Conditioned reflex of Pavlov, Discovery of blood groups
Earth science	Size measurement of the earth (Eratosthenes), Sailing project (C. Columbus), Law of Titius-Bode, Magnitude of star (Hipparchus), Law of uniformitarianism (J. Hutton), Earthquake magnitude (C.F. Richter), Isostasy (J.H. Pratt, G.B. Airy), Theory of continental drift (A.L. Wegener)

March 20003.

The actual study started in March and continued until December 2003. The study results were analyzed in December 2003. To speed up the progress of the study, we developed and applied a science history program which provided students with practice assignments. To verify the study results, we adopted a questionnaire analysis.

The questionnaire about the execution goal was designed by one of the researchers and to test students' scientific attitude and scientific process skills, we used the questionnaire that was developed by Korea National University of Education.

General Scheme of the Study

Activity Theme Selection: At first, a science textbook (for 8th graders) was analyzed. Twenty-three topics about physics, chemistry, biology, earth science were selected through the source collection in science history. The criteria of the selection were whether they provoke interest, whether they help to develop creativity and whether they are easy enough to understand scientific concept. Activity subjects are given in Table 2.

Basic training of inquiry process: We selected a necessary basic factor when a science history related activities are applied to a science history program. Students were trained for it.

Basic training of inquiry process was executed by three steps in the first and second weeks of March. The first step was to learn the inquiry process. It consisted of an inquiry process theory, inquiry process examples. The second step was to

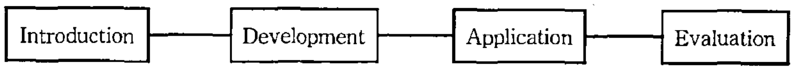

Fig. 1. The model of teaching-learning.

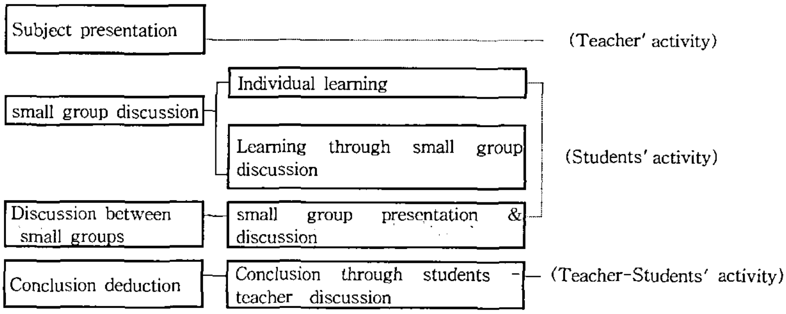

Fig. 2. The model of learning through discussion.

apply the inquiry process. It consisted of making of science history worksheets and method of presentation on three activity subjects. The third step was to establish the inquiry process. It consisted of solving problems after reading science history worksheets.

A teaching-learning model in terms of a science history inquiry process: Our teaching-learning model for the science history program is based on the Korean Educational Development Institute (KEDI) model. The model considers individual variations and efficient class progress and it has been verified by teachers in school for about 10 years since 1972.

The introduction step is composed of the stories about scientists that can motivate students' interest and about the social context in which scientific achievements took place. The development step is composed of the specific study process of scientists thinking process, trial and error, its cause. The application step arranges the concepts about learning content, human's responsibility about science, the social effects of science, the relationship between science and humans, desirable viewpoints about science, etc. The evaluation step determines whether students understood learning contents.

The teaching plan is made unit by unit, and its backside can be utilized after class in self-reflection and for reference data.

Small group discussion activities to improve scientific process skills: According to the seventh curriculum, "students are to engage in inquiry activities and discussions and to express their own opinions clearly and respect other persons' opinions." And it emphasizes studying through the discussion activities. But, the reality does not seem so satisfactory. There are a lot of occasions in which subjective learning does not occur because students depend on teachers. Also, undifferentiated teaching does not allow the opportunity to think deeply for students. Therefore, students need discussion activities to improve scientific process skills. And small groups for discussion activities should be formed so that all members of the group may participate in the activities.

When a group consists of three or fewer members, the members are likely to receive stress due to the heavy burden of participation. On the other hand, for groups with eight or more members, interaction and cohesion tend to decrease because participation will be reduced (Sin and Park, 1997).

We organized three small groups along the dimensions of student's results, personality, sex, physical condition, interaction between the members. In this way, we let the members have intimate contact, and make a cooperative learning atmosphere. Members may move to another group once per month when an obstacle studying happens between members. Each small group has a facilitator, an reporter, a recorder, a deliverer, and a source collector so that each member can take part in small group activities with dignity and a sense of responsibility. Also students change their roles once a month so that they could experience each role equally.

Small group discussion activities were executed according to the model in Fig . 2.

After class is over, self evaluation for discussion activities was made via individual score cards.

Students' reading biography about scientist and journaling their impression: If students know a scientist's life story and his or her discovery process, they can get interested in science and get help in correcting their concepts about scientific truth through subject contents that deal with the scientist's biography.

Thirty-two scientist biographies connected with subject contents were chosen. Students were guided to read more than one book connected with subject content depending on subject progress every two weeks. After reading the book, students wrote their impressions on the book (about a page (A4)). The authors let students make individual reading cards by themselves and grasped how many books students read. To improve the efficiency of the reading activity, a prize was awarded to the student who submitted the best review of a book. And it was posted on the science room notice board to elevate students' reading motivation. In december, a quiz was given on the content books that were required reading. The student who scored highest was awarded a prize.

Locating science history data through the Internet: Students searched for various science history data on the Internet that stimulated their interest and curiosity in an effort to promote learning motivation and scientific thinking ability in science class. Once a month for homework students were asked to search on the Internet science history data that can deepen subject contents--scientist's life stories and daily life science stories related to subject contents.

Results and Discussion

The following are the results of this study.

Performance Results of Task

The students' response to implementing science history program: The students' response to implementing science history program can be seen in Table 3.

1) About comparing the inquiry instruction centered on science history with other types of instruction, the response of very interestingor interestingranked very high. It accounts for 83.3%. It is a surprising result, if this is compared with pre-investigation response of not interesting', which was more than 80%. Therefore, the instruction centered on science history can be a good teaching method for that teacher.

2) Because science history shows processes of building scientific knowledge, the positive response accounts for 75.0%. Students can certainly understand scientific concepts and principles through processes that confirm wrong concepts of many scientists.

3) Today, scientific process skills are considered as very important factors in science education. 75% students agreed that inquiry instruction centered on science history can be an effective method to improve scientific process skills. On the other hand, there was no one that opposes this. This result suggests that the inquiry instruction centered science history is an effective method that can improve scientific process skills.

Table 3. The students' response to implementing science history program (N = 12)

No.	Question	Response	N	Ratio (%)
1	When you compare inquiry instruction centered on science history with other types of instruction, how is it?	Very interesting	4	33.3
		Interesting	6	50.0
		Just so-so	2	16.7
		Not interesting	0	0
2	Is inquiry instruction centered on science history effective in understanding scientific concepts and principles?	Very effective	3	25.0
		Effective	6	50.0
		Just so-so	2	16.7
		Not effective	1	8.3
3	Is inquiry instruction about process that scientific knowledge is attained effective to improve scientific process skills?	Very effective	4	33.3
		Effective	5	41.7
		Just so-so	3	25.0
		Not effective	0	0

Table 4. The students' response of the discussion activity in the small groups (N = 12)

No.	Question	Response	N	Ratio (%)
1	Does the discussion activity centered on science history in small groups help to improve scientific process skills ?	Helped much	2	16.7
		Helped	6	50.0
		Just so	3	25.0
		Did not help	1	8.3
2	What is the average self evaluation result for the discussion activity centered science history in small groups?	More than 90	3	25.0
		8089	3	25.0
		7079	2	16.7
		6069	2	16.7
		Less than 60	2	16.7
3	What is the most positive thing that you got through the discussion activity centered science history in small groups?	Cooperation	4	33.3
		Understanding	3	25.0
		Pleasure	2	16.7
		Presentation	2	16.7
		etc	1	8.3

The students' response of the discussion activities in small groups: The students' response on the discussion activities in small groups is seen in Table 4.

1) When asked Does the discussion activity centered science history in the small groups help to improve scientific process skills?, 66.7% students responded it helped. In general, students positively evaluated discussion activities in small groups. But, teachers need to build circumstances so that negatively responded students (33.3%) may participate spontaneously.

2) The number of the students who gave 80 or more points is larger than the number of the students who gave 70 or fewer points. More students are satisfied with discussion activities. This result displays that many students positively participated in discussion activities in small groups. Also, the authors likewise evaluate.

3) 33.3% respondents responded that a spirit of cooperation occurred among their classmates through discussion activities in small groups. Response that they came to understand their classmates better was 25.0%. 16.7% students responded that science instruction was joyful and that their presentation ability was improved. Other response (scientific process skills was improved, concentration ability was improved, etc.) was 8.5%.

The students' response on giving more chances to inquiry activities: The students' response on giving more chances to inquiry activi-

Table 5. The students' response on giving more chances to inquiry activities (N = 12)

No.	Question	Response	N	Ratio (%)
1	Does "Reading biography about scientist and writing impression of book" help in science history inquiry activities?	Helped much	2	16.7
		Helped	5	41.7
		Just so	3	25.0
		Did not help	2	16.7
2	Does "Finding science history data on the Internet" help to improve scientific process skills?	Helped much	4	33.3
		Helped	6	50.0
		Just so	1	8.3
		Did not help	1	8.3

Table 6. Scores about a survey of attitude. ① Strong affirmation ② Affirmation ③ Just so ④ Denial ⑤ Strong denial

Classification	①	②	③	④	⑤
Affirmative sentence	5	4	3	2	1
Negative sentence	1	2	3	4	5

Table 7. The change of perception of science. SD*: standard deviation, Sig.**: significance

Classification	Mean		SD*		t-value	Sig.**
	Pre	Post	Pre	Post		
Perception of science	3.04	3.30	0.56	0.55	2.25*	P<0.05
Perception of science education	2.88	3.20	0.49	0.46	2.53*	P<0.05
Perception of scientist and job related to science	2.84	3.00	0.43	0.31	1.65	P<0.05
Perception of mutual relativity of STS	2.68	2.98	0.39	0.37	2.44*	P<0.05

ties is seen in Table 5.

1) 58.4% students responded that Reading biography about scientist and writing impression of book helps to science history inquiry activities. In general, respondents responded positively. But students who responded negatively felt burdensomeness on task performance.

2) Most of students (83.3%) responded that Finding science history data in the Internet helped to improve scientific process skills. Therefore computer aided instruction needs to be developed with comprehensive and continuous interest.

The Change of Attitude Towards Science

The change of attitude towards science was measured by the questionnaire that Kim et al. (1998) developed. This paper consists of three areas on science-perception, interest, and attitude. And there are 16 small scopes. Each small scope consists of three items. Thus the total items are forty eight. Cronbach, the item inter-consistency on perception and interest was 0.83, and that on attitude was 0.87. Standard deviation of each item was 0.81.2. Likert scale as in Table 6 was used to analyze attitude change towards science.

The change of perception towards science: The students' change of perception towards science is seen in Table 7.

In investigation of perception related to science, mean of perception about science was shown the highest value among 4 items. This is so, we believe, because most students denied strongly the statement-contents learned in science instruction are not applicable to the real life. This is because the voluntary learning method is established in some degree through the science history centered inquiry activity. All 4 items--perception about science, perception about science education, perception about scientist and job related to science, perception about mutual relativity of STS--show meaningful difference in t-test, which shows that perception of science was positively affected by the science history program.

Table 8. The change of interest in science

Classification	Mean		SD		t-value	Sig.
	Pre	Post	Pre	Post		
Interest in science	2.82	3.19	0.42	0.52	2.90*	P<0.05
Interest in science learning	2.79	3.21	0.39	0.68	3.18**	P<0.01
Interest in activities related to science	2.84	3.23	0.33	0.56	2.90*	P<0.05
Interest in job related to science	2.66	2.99	0.4	0.51	2.60*	P<0.05
anxiety about science	2.88	3.08	0.38	0.37	1.86	P>0.05

Table 9. The change of students' scientific attitudes

Classification	Mean		SD		t-value	Sig.
	Pre	Post	Pre	Post		
Curiosity	2.90	3.20	0.36	0.43	2.42*	P<0.05
Openness	2.90	3.17	0.44	0.44	2.26*	P<0.05
Critical ability	2.68	2.82	0.30	0.33	1.51	P>0.05
Cooperation	2.93	3.21	0.25	0.32	2.37*	P<0.05
Voluntary	2.57	2.71	0.42	0.97	1.46	P>0.05
Perseverance	2.82	2.92	0.37	0.44	1.59	P>0.05
Creativity	2.86	3.32	0.27	0.35	3.45**	P<0.01

The change of interest in science: The students' change of interest in science is seen in Table 8. Science is recognized as an uninteresting and boring subject to most students. But students can have interest in science through science history centered inquiry activities. The change of students' interest--interest in science, interest in science learning, interest in activities related to science, interest in job related to science--show a meaningful difference in t-test.

The change of scientific attitudes: The change of students' scientific attitudes is can be seen Table 9.

In the survey of scientific attitudes, most of students answered affirmatively to the question-I try to search for a new method to solve some problem. This indicates that students' creativity was considerably improved through the science history program. Also it shows that curiosity, cooperation and opennesshad a significant change. But voluntary, critical ability and perseverance showed poorer results than expected. Voluntariness scored especially low points. This agrees with the result of small group discussion activities. So teachers need to create opportunities so that negatively responded students may participate spontaneously in the small group discussion activities.

The Change of Scientific Process Skills

The change of scientific process skills measured by test paper that Kwon et al. (1994) developed. The ten inquiry factors--observation, classification, measurement, prediction, inference, data conversion, data analysis, hypothesis set, controling variables, generalization etc.--were measured through this questionnaire, and t-test was enforced. The reliability of this test tool is 0.69, each inquiry factor consists of three problems--total thirty problems.

The change of the students' scientific process skills is seen in Table 10.

According to the survey on the effects on scientific process skills' improvement through a science history program, the highest mean was seen in 'observation' and 'measurement' of basic inquiry areas. And the highest improving ratio appeared in 'measurement' and 'classification', the lowest improving ratio (7%) appeared 'ininference'. It showed a meaningful difference not only in 'measurement' but also in 'observation' and 'predic-

Table 10. The change of scientific process skills. MD*: PrePost mean deviation. Ob[1]: observation, Cl[2]: classification, Me[3]: measurement, In[4]: inference, Pr[5]: prediction, DC[6]: data conversion, DA[7]: data analysis, HS[8]: hypothesis set, CV[9]: controling variables, Ge[10]: generalization, BIA[11]: basic inquiry area, TIA[12]: total inquiry area.

Classification		Total (%)		Mean (%)		MD* (%)	SD		t-value	Sig.
		Pre	Post	Pre	Post		Pre	Post		
BIA[11]	Ob[1]	24(53)	28(62)	1.6(53)	1.9(63)	0.3(10)	0.5	0.5	2.26*	P<0.05
	Cl[2]	20(44)	25(55)	1.3(43)	1.7(56)	0.4(13)	0.6	0.6	2.65*	P<0.05
	Me[3]	23(51)	29(64)	1.5(50)	1.9(63)	0.4(13)	0.6	0.7	3.06**	P<0.01
	In[4]	20(44)	23(51)	1.3(43)	1.5(50)	0.2(7)	0.7	0.7	1.87	P>0.05
	Pr[5]	21(46)	25(55)	1.4(46)	1.7(56)	0.3(10)	0.6	0.6	2.26*	P<0.05
TIA[12]	DC[6]	18(40)	22(48)	1.2(40)	1.5(50)	0.3(10)	0.9	0.7	1.33	P>0.05
	DA[7]	15(33)	19(42)	1(33)	1.3(43)	0.3(10)	0.7	0.6	2.26*	P<0.05
	HS[8]	12(26)	15(33)	0.8(26)	1.0(33)	0.2(7)	0.7	0.5	1.87	P>0.05
	CV[9]	12(26)	14(31)	0.8(26)	0.9(30)	0.1(3)	0.8	0.7	1.47	P>0.05
	Ge[10]	16(35)	20(44)	1.1(36)	1.3(43)	0.2(7)	0.5	0.5	1	P>0.05
Total		181(40)	220(49)	12.1(40)	14.7(49)	2.6(9)	2.2	2.5	2.46*	P<0.05

tion' in t-test. These results are interpreted as follows. Basic training in the inquiry process greatly influences for that test and the difficulty index of basic inquiry area is relatively low. The highest improving ratio was seen in 'measurement', but the highest mean value was in 'observation'. Because 'classification' and 'inference' are relatively low, students need intensive training in these areas. After our science history program was executed, it shows a meaningful difference in all inquiry factors of basic inquiry areas except for 'inference' in t-test. This indicates that the science history program contributed significantly to improving scientific process skills.

Because the difficulty index of the total inquiry area was relatively high, the value of total scientific process skills was lower than basic scientific process skills. Data conversion's value was 40 points, and remainder was as low as 2030 points. Especially, the areas of Controling variables and Hypothesis set scored lower points.

The results of this study indicate that it is wrong for teachers to unilaterally present problems to students to improve scientific process skills. Teachers must present the problems so that learners may recognize them by themselves. And teachers will have to offer students new problem circumstances through intimate and interesting inquiry activities.

Summing up, scientific process skills of students improved by 9% after the application of our science history program. These results prove that our science history program is effective in improving students' scientific process skills.

Conclusion

Conclusion This study was performed to investigate how effective a science history program is in changing students's scientific attitude and in improving their scientific skills. In the program, students collected science history data related to the subject contents, a science history program was developed and applied to inquiry activities, and teachers created circumstances in which inquiry activities could be executed.

Through this study, the authors came to the following conclusions.

1) The science history program was effective in understanding scientific concepts and principles. It elevated students' perception towards science, i.e., science education, scientists, and jobs related to science. Also it greatly elevated students' interest in scientific inquiry activities.

2) Students' scientific attitudes--curiosity for science learning, creativity, cooperative spirit, etc.--were stirred up. Students were interested in activi-

ties related to real life science. Students tried to apply scientific process skills getting through science inquiry activity to their life.

3) Students had active attitudes toward solving problems through small group discussion activities and searching for science history data on the Internet. The small group discussion activities gave positive effects in respecting other peer members and cooperating with them.

4) By offering opportunities for inquiry activities, students escalated their logical thinking ability one step higher. A meaningful difference is shown in scientific process skills--measurement, observation, prediction, data analysis, etc..

5) Students improved their abilities to think independently through problem solving practice. Also students gained confidence in solving problems.

Proposals in Future Studies A. This science history program has been developed for 8th graders. When this science history program is appropriately modified for other graders in future studies, the purpose for choosing such science instructional programs will be to make more students perceive science classes to be easy and fun.

B. Since it was hard to obtain teaching materials and resources related to science history, there were several impediments to develop a science history program. For this reason, it may be difficult for teachers to introduce a science history in teaching activities. If sufficient resources is accumulated later on, teachers can be expected to utilize this program in their teaching activities.

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