# Is It an 'Educational' Activity?: The Case of a High School Biology Laboratory Class

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**Abstract:** There have been many attempts to determine the value and the role of school laboratory experiment, but it seems hard to find consensus among these attempts from the perspective of education. This difficulty seems mainly due to disagreement on the concept of education, which has caused an instrumental attitude considering the school laboratory only as a means of developing science or pursuing various functions of school. However, the Endogenous Theory of Education (ETE), which claims education as 'a form of life', has recently paved the way for laboratory experiment to be justified as an opportunity of 'educooperation' allowing students to experience the intrinsic values of education in the medium of science. According to this theory, it is not the detailed practicals but the whole context where the laboratory activity is situated that matters in revealing the inherent educational phenomena. Through this new perspective, I observed two biology laboratory classes in a high school and analyzed the pattern of teacher-student and student-student interactions. Some meaningful educooperation was found in students' chattering, which has been traditionally considered as merely noise in the classroom, rather than in teacher-student interactions. This study discusses the reasons for these findings in detail and culminates in suggesting ways for accentuating the educational aspect of school laboratory activity.

Key words: ETE (Endogenous Theory of Education), school laboratory experiment, educooperation.

## I. Introduction

Laboratory experimentation has been an important topic in the study of science education since the end of the 19th century(Armstrong, 1903; Turner, 1927; DeBoer, 1991). In particular, the science curricular reform of the 1960s, which emphasized the inquiry of science, the process of science, and the development of higher cognitive skills in general, accelerated research on laboratory-centered science education (Bruner, 1961; Schwab, 1962). It was believed that there would be rich benefits in teaching and learning science from laboratory activities which would even compensate for the vast amount of needs, such as time, efforts and expenses (DeBoer, 1991; Bybee and DeBoer, 1994; Bybee, 1997).

On the other hand, some research has seriously questioned the effectiveness and the role of laboratory experiment in school science (Kerr, 1964; Shulman and Tamir, 1973; Hofstein and Lunetta, 1982; Lazarowitz and Tamir, 1994, Hodson, 1998; Woolnough, 1998). As a matter of fact, reports showing the laboratory teaching is not as self-evident as it once seemed are increasing(Woolnough, 1995; Hodson, 1996, 1998; Nott and Wellington, 1996; Lunetta, 1998; Wellington, 1998). Quite a few research papers have discussed students being more concerned with the results of the experiment and with obtaining good grades rather than with the enjoyment of participating in the process of science itself (Woolnough, 1995, 1998; Gott and Duggan, 1996; Lunetta, 1998; Hart, 2000). Many attempts have been made in science education research to deal with this situation.

Research in relation to the teacher's role and responsibility for initiating laboratory activities, maintaining activity flow and monitoring student work have suggested a wide variety of technical treatments based on psychology and sociology(Babikian, 1971; Tamir & Lunetta, 1981; Klopfer, 1990; Gott & Duggan, 1996; Tobin, 1987; Gallagher, 1985). Many research papers have focused on the implementation of science curricula with fine tuning of the cognitive

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psychological and epistemological perspective of students' practice(Mathews, 1994; Driver, 1994; Hodson, 1998). Developing more general skills, such as communication and argumentation skills, is being actively reviewed along with resetting the goals of school laboratory toward scientific literacy(Hart *et al.*, 2000; Kim, H., 2003). In the context of scientific literacy, some research has placed stress on enculturation role of the school laboratory into the scientific community(Roth, 1995; Hodson, 1996, 1998; Wellington, 1998).

However, all the efforts mentioned above seem to be too divergent to lead us to a definite idea of what the 'educational aspect'of the school laboratory experiment would be and therefore what the 'educational problems' of it would really be. Han (2004a, 2004b) pointed out that this uncertainty was due to the fact that the concept of education in science education research was confused with all sorts of practical paraphernalia related with the school environment, called 'schooling'.

As a matter of fact, 'education' has been traditionally used as an umbrella term to include all the issues and agenda around the school in much education research(Atkin, 1968; Brockman, 2005; Chang, 1986, 1990, 1991; Lagemann, 2000). Han (2004a) showed that quite a few research efforts involving the school laboratory, if not all, have been mostly concerned with 'schooling' problems rather than with theoretically grounded issues aroused by the concept of education; furthermore, most studies have focused on how the functions of the school laboratory are related with the development of science and the various goals of school rather than revealing the educational aspect itself of the school laboratory. Therefore, all sorts of exogenous perspectives and methodology, such as ones originated from disciplines of psychology, sociology, and anthropology, could be permissive to the educational aspect as mentioned above.

With understanding the facts described above, this study tries to conceptually separate the educational aspect of the school laboratory experiment from other aspects driven by exogenous disciplines or 'schooling'. In this new context, the meaning of 'education' in school laboratory experiment is expected to be revealed 'exclusively'. The revelation of educational meaning of the school laboratory experiment will help to theorize and to realize the opportunity of educooperation between the teacher and the student or among the students.

To verify this hypothesis, this study applied the Endogenous Theory of Education (ETE)(Chang, 1994c, 1998, 2005) and analyzed the structure of high school biology laboratory classes. With non -participated class observation, the structure of the school laboratory experiment was observed and analyzed from the perspective of ETE to explore the possibility of it as a meaningful educational activity. This research culminates with suggesting a new model of school laboratory experiment as an 'educooperation', consisting of its own subordinate activity elements of 'ascending education' and 'descending education' not dependent upon any other external factors.

## II. New Approachment: the Endogenous Theory of Education (ETE)

### 1. The Endogenous Theory of Education

The Endogenous Theory of Education (ETE) is an educational theory recently proposed by Chang (1994c, 1998, 2005). ETE begins on the grounds that the previous study of education has been misdirected as follows. Firstly, the previous study of education has defined education functionally and has made no rigorous attempts to reveal its nature with a self -regulatory discipline(Chang, 1986). Secondly, the previous study of education has called itself an applied science and imported research results from other disciplines, such as philosophy, psychology, and sociology, without sharp distinction of education from them. Thirdly, the previous study of education has considered the sum of such heterogeneous disciplines can assert the study of education of its own in the academic community(Chang, 1990, 1991).

To correct this situation in the study of education, Chang proposes a new idea of education which is supposed to have its own totality with a certain structure as other various domains of life(1994c). He asserts that the study of education has to contrive its own theoretical concepts to distinguish education from other disciplines(Chang, 1994a). According to

ETE, to understand what education is not a matter of concept-definition, but of finding its structure; thus, 'the context' where education is situated has to be emphasized to construct a theoretical framework that catches the ubiquitous educational phenomena in our lives.

The history of human beings shows that there are many ‘transcendental realms’, such as science, art, meditation, zen, yoga, and judo, where a man has realized his own latent possibilities or potentialities only through the inner compass of his mind. The participants in each transcendental realm seem to pursue the unique intrinsic values and confirm them through personal experiences. The realization of each transcendental realm has been testified historically but its existence can be proved only by the persons who experience them(Chang, 1994b). Therefore, every transcendental realm cannot but have many developmental stages of the participants similar to a ladder, called ‘transtalent’. Since no one has reached the final or ultimate stage, the transtalent is always a relative standing in the hierarchy of the transcendental realm.

It is between the different levels of transtalents in a specific transcendental realm where ‘education’ occurs with an autonomous structure of its own. Education is composed of two processes which facilitate the vertical development of humanity. One is ‘ascending education (AE)’ and the other is ‘descending education (DE)’. AE is the process of developing higher transtalents based on the participant's present level, while DE is the process of transmitting his desirability to other persons. Each of them has different devices permitting the participants to go up and down the vertical hierarchy of transtalents respectively.

AE and DE make up a whole structure, while maintaining their own subordinate elements. Both processes are not only complementary to each other, but also reveal a holistic new character that cannot be reduced to individual ones. It is assumed that every person occupies his own transtalent at a specific level in a specific transcendental realm. Therefore, when two persons meet, there is a possibility of interaction between them in such a way that the person with higher transtalent, the ‘more advanced’, participates in DE, while the person with lower transtalent, the ‘less advanced’ participates in AE. The peculiar features of this interaction make up the totality of education. When this happens, another holistic structure, called ‘educooperation’, appears.

Educooperation constitutes a unique structure by itself. The surprising characteristic of this structure is that there are respective elements whose meanings are decided by the relations among themselves. More importantly, the meanings of those elements are not dependent on external facts outside the structure. The structure of educooperation is more like ‘a wheel’ (Chang, 1998, 2005), as shown below(fig. 1).

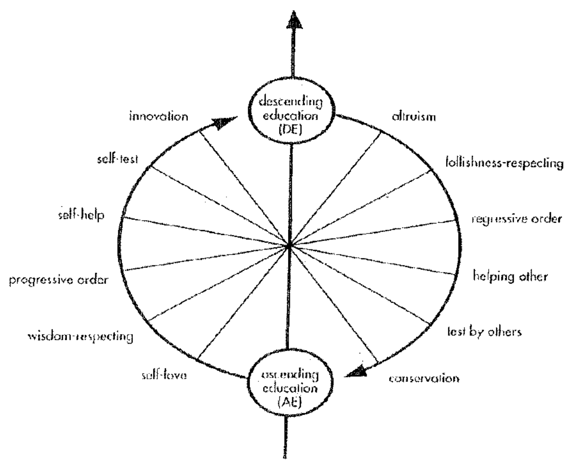


**Fig. 1** *A Wheel of Education*

Source:
Chang(1998). Epistemological significance of educational relationship. *Korean Social Science Journal, 25*(1), 21-61.

In the figure, AE and DE have six contrasting elements to each other. Each AE and DE has a unique whole composed of their own elements, and they make up a cooperative system with contrasting elements. The six elements of each world are syntagmatically related and contrasted paradigmatically as an autonomous world. They show motive of action, subjective meaning of results, relative perspective, arrangement of stages, forms of transformational activity, and validation of greatness.

2. Reconceptualization of science education

Science education can be reconceptualized from the perspective of ETE. To begin with, we need to assume that the scientific knowledge is a translatent which has always had a relative standing in the hierarchy of the world of science. Next, the world of science has to yield its position as ends or goals of science education to the world of education because it needs to take part of the axis of the educooperation structure. In other words, scientific knowledge needs to be treated as a means or material for educational practice. In this respect, science education can be pursued as a holistic structure of 'educooperation' on the ladder of science.

In this new context, the specific purpose of science education is to sustain and develop the educooperation itself rather than to level up the translatent in the world of science. This concept of science education opens a possibility for the laboratory experiment to possess the meaning of an educational activity, and thus provides the theoretical foundation to explain the prototype of the laboratory experiment in school science whose aim is to realize the value of education above all.

The relationship between the teacher and the students used to be difficult to categorize into an educational form in the traditional school laboratory. Separation, conflict, and collision between the teacher and the students or among the students are inevitable because they insist their own view of truth in their present level. Any attempt to bridge this gap directly through the communication of language is quite reckless and unreasonable as if trying to climb up to the roof a house without a ladder. Omitting the activities that fill the gap with necessary experiences only incurs an unnecessary and wasteful conflict.

However, this problem can be solved in the new context of science education. There is no requirement for the student to have an absolute translatent in science in order to participate in science education because science is only a means of validating intrinsic values of the world of education at his present level. It is a basic presumption of education that no one is free from mistakes and foolishness. The educational space between the teacher as a 'mentor' and the student as a 'disciple' is filled up through the inner rule of education until the disciple surpasses his master, which means the utmost recompense for his mentor's teaching and the victory of education.

This study applied this new concept of science education to reveal the neglected points in the traditional science education research on laboratory experiment. It also aimed to find out the key components consisting the structure of laboratory experiment as an educational activity. To visualize and verify this idea, the patterns of the activities in the biology laboratory classes were observed and reinterpreted in the context of the reconceptualized science education. A new model of school laboratory in the perspective of education is suggested at the end of this paper.

## III. Methodology

### 1. Methods and procedures

This study was pursued by qualitative research method based on a case analysis of high school biology laboratory classes. The analysis required a contextual or naturalistic approach because this study aimed to uncover the traditional configuration of school laboratory. Therefore, non-participant observation was applied with videotaping and recording. Interviewing was performed with the teacher and the students in order to gauge their intentions in the laboratory class.

In this research, there is an assumption that the educational aspect of the laboratory experiment has not been fully revealed yet because the concept of education has been confused with schooling. It is necessary to verify whether the meaning of education is automatically endowed to the laboratory experiment in school science only because it is one of the activities pursued in school. Therefore, my theoretical research also thoroughly delved into ETE, and the analysis criteria for the laboratory class were set by a reconceptualization of science education based on ETE.

It should be pointed that ETE was applied to this research not only as the basis for the analysis criteria of the laboratory class, but also to the research methodology. In education research, including science education studies, it is not difficult to find a trend of accepting the qualitative research method with the expectation of making education appear as one of the cultural facts in a certain society. That method might be suitable to the study of anthropology, but not to the study of education. It would be a categorical mistake to reduce 'education' to 'culture' if we were to allow the use of ethnographical methodology in the study of education while omitting 'educational inference' by a well grounded education theory.

To find a suitable study case for this research, a survey was conducted during the period of February through March, 2004, starting with the schools nearby; however, web sites and TV programs related with science education cases were also reviewed. Finally, H high school in Seoul was introduced through a KBS documentary program involving H high school's technology laboratory class, and it was decided to take H high school as a case for this study. At that school, I met a biology teacher, P, who was more interested than his colleagues in teaching the laboratory class.

Generally speaking, it is not easy for science teachers to pursue laboratory classes in high schools, especially in Korea, because the science classes mostly involve preparation for college entrance examinations. However, teacher P thought doing an experiment should be the first thing to be emphasized in science education, and indeed he tried to carry this belief out himself regardless of unfavorable conditions for doing so. Of course, his noteworthy endeavor toward the laboratory classes could not automatically guarantee that his classes would be 'educationally better' than those of other teachers, and we would be unable to determine that before 'educational evaluation'[1] was actually performed. However, the possibility existed for P to be motivated to seek for the possible intrinsic values of lab activities, because it is hard to perceive him as being driven by external reinforcement since there were no extra payment or results-based payments for the teachers at that school.

Two groups of 11th grade girls' classes were observed during the month of May, 2004. Each group worked on the same series of experiments consisting of five different subjects. All the experiment classes for each group except the first ones were video taped. Interviews with the teacher and some students were also pursued. The interviews were recorded as well as written down instantly. The interview records were always open to teacher P, so that he could reflect on his own practice, and also so that I could observe his responses for further analysis. This process was helpful for both of us because it developed his understanding of education, and aided me in understanding what he really meant by his talk and performance on the other hand.

Some limitations in this study should be pointed out. The purpose of this case study is to analyse a typical structure of laboratory experiment in school science, but there is a possibility of exaggerating the representativeness of the case. As a matter of fact, the style and structure of laboratory classes can vary depending on various factors, such as type schools, specific subjects, and the purpose of doing the experiments, and so forth.

Another thing to point out is related with generalization of the case, which must depend upon the perspective of the researcher. Even though H high school laboratory class was selected as a suitable one for this study, it might have some limitations for other analysis with different purposes. However, it is inevitable to throughly describe only a case because qualitative research, especially a case study, includes the process of screening the case suitable for the purpose of the research. Therefore, the generalization problem might not be severe in this study. As mentioned earlier, since the case was selected to verify the hypothesis of this study, the generalization is not a significant problem in this study.

A more fundamental limitation comes from the etic perspectives of the researcher. It is possible for the emic stands in the school laboratory to be covered by the etic stands of the researcher because this study was pursued with the purpose of verifying the hypothesis of the researcher. To prevent this, I searched for all the clues indicating emic stands through a careful investigation and analysis of the class observation and the interviews, but over all, there is still a possibility of being doomed by etic stands and of covering some emic points.

## 2. Participants

Two groups of 11th grade girls' classes were observed during the month of May, 2004. One group was composed of 30 students in a science course,

1) In this paper, the term 'educational evaluation' has also been reconceptualized through ETE(see Chang, 2005).

and the other one was composed of 37 students in a liberal arts course. In each group, the students were divided into teams, and shared a large bench with the team. The student group on the science course were divided into four teams consisting of eight members each except for one team which had six members, while the student group in the liberal arts course were divided into five teams consisting of eight members each except for one team which had five members. Both groups worked on the same series of experiments consisting of five different subjects. The duration of each laboratory class was 50 minutes. The subjects and the schedule of the experiments are summarized with indicating codes as follows. For instance, SE1 means the first experiment of the student group in the science course.

**Table 1**
*Contents of Experiments*

| Order | Title | Student Group |
|---|---|---|
| E1 | Is everything growing alive? | SC, LC |
| E2 | Confirmation of nutrients in food | SC, LC |
| E3 | Analysis of the factors affecting the function of digestive enzyme | SC, LC |
| E4 | Observation of blood components | SC, LC |
| E5 | Verification of blood type | SC, LC |

E1 is to compare the growth of ferrocyanide potassium crystal and that of a living organism in order to help students develop some ideas about what life is. The activities in E1 are mainly composed of watching the growth of a crystal. E2 through E5 are more inquiry-oriented experiments than E1. E2 is first to make the solutions of corn starch, bean oil, egg white, and glucose representing carbohydrates, lipid, protein, and glucose respectively, which are presumed to be the main nutrients in food, react with some indicating solutions, such as a Benedict solution and an Iodine solution and then to watch what happens to those reactions. E3 is used to analyze the factors affecting the role of ptyalin in human saliva. The diluted saliva solution treated with ice, hydrochloric acid, sodium hydroxide, heat, and room temperature separately, is made to react with the Iodine solution. E4 is to observe the components of blood. Collecting blood from the finger tip, making a slide of the blood after staining it with Gimsa solution, and watching the components of blood under the microscope are the major steps of E4. E5 is used to verify the human blood type. Three droplets of blood from the finger tip are mixed with anti-A, anti-B, and anti-Rh serum separately on the slide. Students are expected to verify their own blood type after watching the reaction.

### 3. Criteria for analysis

The criteria for analysis of the laboratory activities are mainly based on the six key elements of the 'intrinsic rules of education', which are the motive of action, the subjective meaning of results, the relative perspective of knowledge, the arrangement of stages, the forms of transformational activity, and the validation of human greatness(Chang, 1998). All the laboratory activities from E1 through E5 of both groups were divided into individual and interpersonal level and evenly analyzed. The patterns of analysis are summarized below.

**Table 2**
*The Criteria of Analysis*

| | | |
|---|---|---|
| Individual Level | Teacher | 1. the motive of activity<br>2. the meaning of results<br>3. the perspective on scientific knowledge |
| | Student | 4. the arrangement of activity<br>5. the forms of transformational activity<br>6. the validation of human greatness |
| Interpersonal Level | interaction between teacher and student | |
| | interaction between student and student | |

## IV. Results and Discussion

### 1. Activities at the individual level

<Student>

From the standpoint of students, the motive of doing the experiments might be described as rather extrinsic because they lacked the option of not doing it under the school curriculum. They just had to show up to the class scheduled, and were made to participate in it. Even under this situation, however, I could find some students voluntarily showed their personal interests in the experiment. At the end of LE3, I had a chance to talk with a student.

Researcher: Why are you doing this experiment?
Student A: Because it's fun. and it helps me understand what the teacher says.

Students recognized the experiment results as something new and curious. While looking at the reactions, even though the results were far from the teacher's expectation, the students cheered and shouted with joy. When the students observed a beautiful crystal starting to grow in LE1:

Student B: Wow! That's marvelous. It's getting bigger.
Student C: Awesome, it really grows!

However, the students did not seem to commit themselves to the results from their inner minds, and thought the results would be objective. For instance, some students in SE2 grimaced with suspicion while looking at the test tube, but at last they just decided to follow after the judgement of the teacher, and wrote down what the teacher said on their work sheet.

Teacher: Let's see, the Benedict reaction...(toward student team 4)
Well, it looks like not being diluted properly.
Student Team 2: How about this, sir?
(asking the teacher with voices lacking confidence)
Teacher: Oh, that's good, very well done.
Student Team 2: Great!
(they turned up their voices high with satisfaction)

The students were likely to think there should be a definite and objective answer for the experiment. Therefore, they think they should respect the teacher's opinions. However, this perspective on scientific knowledge worked as a hindrance to the students in thinking more creatively, shrank their confidence, and forced them to guess what the right answer would be all the times. For instance, all the students in SE1 and LE1 wrote down answers to the question, "Why aren't the crystals alive even though they grow?", as follows:

1. They are not composed of cells.
2. They don't metabolize.
3. They don't have homeostasis.

It was very surprising that they 'already knew' the answer regardless of the end results of the E1. There were no ways for them to find out any of those three answers through E1 because it was only an observation of the growing crystals.

There was a tendency toward forcing the students to follow the schedule in the curriculum, in the text book, and in the order of the teacher. That means the arrangement of the activities was far from following the specific rate of individual student's progress in structuring the knowledge. Therefore, the form of students' activities did not enable them to enthusiastically help themselves. They adopted a passive style rather than an active, self-helping style. Students hesitated to confirm the results by themselves, and showed a tendency to lean on a definite answer, mostly the teacher's explanation. When Student Team #5 in LE3 happened to be puzzled with the reactions because all six test tubes turned to be the same color without any changes, this is how they acted:

Student T: Sir, there is something wrong with this.
Student R: Why are all of these the same?
Student E: No changes? Rats!

After showing some disappointment, they started to talk a way to escape their predicament. They looked around at other teams' work, searched for the right answers in the text book, and asked the teacher for help. At the time the students were asked to submit the report, they quickly rigged up a result.

<Teacher>

From the standpoint of the teacher P, the motive of directing the experiment was somewhat intrinsic.

Teacher: Practically it's very hard to do experiments at school. Today, I came here at 6:00 a.m. to set up the tools and prepare materials for five classes. It's only me, you know,..myself, to do that. That's not the end. After the classes are over, I have to clean them up all by myself. The only reason I do this, however, I just think so. That's my own 'responsibility' as a science teacher.

Even though he used the term 'responsibility', from the following conversation I could recognize that it meant his passion for teaching.

Researcher: As a science teacher, what do you think about the current tendency for kids in our society to avoid being science major?

Teacher P: Well, as a science teacher, I think the reasons are related with their experiences in science classes at school. Students get bored with science classes requiring lots of memorization or are intimidated by difficult questions. However, these problems can be somewhat lessened by a teacher who tries to make them become involved in the process of science, the experiment. At last, it is the teacher that has the key to make a student's mind move toward science.

Teacher P recognized the experiment results as being well-established and typical. Whenever the students showed their results to him, he tried to explain the reason why their experiment worked or why it did not work. Giving these explanations might have been kind of boring for him as he to repeat the same thing over and over when different student groups came to him. He seemed also to think there should be a definite answer out of the experiment and that this answer should have objective value regardless of the students' understanding level. However, as a result, that attitude toward knowledge seemed to prohibit the students from thinking creatively because the students tended to guess the answers held by the text book or the teacher rather than expose their own questions and answers and develop them.

There was a tendency for Teacher P to be forced to follow the usual curriculum schedule. As a result, he lacked the freedom to be flexible and unable lower or raise the level of his activities to match the students' levels at a given moment. The type of teacher's help was usually direct. When the students were puzzled with some problems, Teacher P usually gave them his own answers right away instead of leaving room for the students to reflect upon the specific questions and find the corresponding answers on their own. Here is a scene related with this situation at LE3:

Student Team 3: There is something wrong. Why are the colors the same? And no changes ever!!

Teacher: Did you heat the test tube F at 70-80C before starting the reaction? It is necessary for the structural change of the protein. As I said, solution A is the control, and solution F is made to compare the effect of temperature on ptyalin.

2. Activities at the interpersonal level

<Teacher - Student>

There were many uni-directional activities observed which seemed far from interaction. The teacher's explanations were accepted without question from the students. Few questions were aroused by the activities. Even though the teacher tried to show some samples and demonstrations, his overall activity was in the configuration of transmitting the knowledge from the text book. For example, the teacher spent 25 minutes explaining cautions and explanations related to the procedures as the students just listening. During this situation, students, especially those whose levels were significantly below the lecture subject level, seemed to be having difficulty in concentrating and finally lost interest.

In turn, the students who lost interest in the subjects usually found it difficult to concentrate on the experiments. To motivate these students, the teacher tried to cheer up them with funny jokes, and sometimes warn them about the examinations and quizzes. However, the reactions from the students were insufficient in overcoming the boredom; strikingly, most of the teacher's time was spent controlling and managing the students. Students who sit close to the teacher somewhat tried to write down what the teacher said, but the students who were sitting far from the teacher did not listen to him and talked with other students.

<Student-Student>

Students were very interested in watching the scene and explaining it in their own words. While this interest led them to enthusiastically share their thoughts, it also naturally led to noisiness in the classroom. Students frequently talked and asked each other questions during the experiment, especially when something was ambiguous or when the practicals did not go well. Here is one of the episodes from LE3.

> Student G: What's this? There must be something wrong.
> Student K: Yeh, mine looks the same. The colors are all the same. No changes at all.
> Student G: Did we miss something?
> Student K: No, I swear I didn't miss anything.
> Probably the incubation time is related, or the temperature of water...
> Student K: Oh, that's right. Maybe both the factors were connected.

There were definitely more active interactions among the students in comparison with those between teacher and the students. Students were quite serious, and tried to find the meaning in what they were doing. They were even eager to persuade their friends to agree with their opinion. However, all these activities and conversations among the students were treated as noise and pandemonium which must be controlled and managed. As a result, serious discussions did not occur between the teacher and the students.

### 3. The Barriers to Change

#### 1) The Function-Oriented Configuration

The first reason why the attitudes of the teacher and the students and their interpersonal activities were far from being 'educational' was due to the function-oriented configuration of the laboratory activity. Instead of letting the students enjoy participating in the experiment itself, students were derived to use the laboratory to find the given answers, and match the results with the given problems or hypothesis. Furthermore, the tasks of the students were measured and recorded according to a set numerical method in order to be reported to a higher institution or used for some purpose other than giving value to education itself.

The former case reflects a situation where the laboratory activity is being used to pass scientific knowledge to the next generations and the latter case means the laboratory is used for a variety of functions of school beyond education. In either case, the evaluation system of the student laboratory activities drove students to consent to the standard rather than to be involved in creative thinking through the experiment. In many cases, the teacher seemed to attach the purpose of doing an experiment to the observation or confirmation of scientific facts. Here is a situation showing this attitude at SE2.

> Teacher: Look at this! (while indicating one of Student Team #1's tubes)
> This result is too dark because you put in too much Iodine solution.
> OK, Next!
> Who did this Buret reaction?

The teacher ended the class by giving fixed answers to the students matching those in the textbook. The students wrote down the answers in their reports right after the teacher spoke, while there were some students whispering their disagreement with the given answers from the teacher or with the discrepancy between the results and their expectation.

Most of all, 'the result of the experiment' was thought to have objective value because it was evaluated on the basis of the definite answer. Since the purpose of the evaluation of the laboratory activity was set to grade the student, every student was considered as the objective for the evaluation while the teacher had the 'only' right to evaluate the laboratory activities. As a result, the students seemed to focus on the results of the experiment rather than the process of inquiry itself, eventually making the students passive. The students had a tendency to guess the 'right' answer all the time in order to receive a good evaluation. As a final result, the lab activity became ritual, meaningless, and time consuming.

#### 2) Misunderstanding of education

Misunderstanding of the principles of education rising from the confusion of education with 'socialization' and 'enculturation' can be depicted as another factor in creating hindrances for the school laboratory activity to be an educational opportunity. For instance, Roth(2000), Hodson(1998), and Wellington(1998) have pointed out that school a laboratory activity needs to be an opportunity for students to adapt to the scientific community. They think the student lab has to be an enculturation process to the scientific community, for the laboratory experiment at school to be 'authentic inquiry'.

The concept of education is theoretically distinguished from that of enculturation and socialization. Even though the concepts of socialization and enculturation are still arguable in the fields of sociology and anthropology, it is certain that both of them have tendency to put stresses on the results and functions of a work rather than finding the intrinsic value of itself (Nyberg & Egan, 1981). However, education is a very unique form of life related with emergence of totally new human nature, placing it significantly above adaptation, and attaching values to the process of itself.

If education is equally conceptualized with the socialization and enculturation at school, or at least not distinguished from either process, the school laboratory experiment cannot have more meaning than a tool or a menas used for transferring the pre-made knowledge. In this context, the students are expected to adapt and adjust to the frame of formal scientific knowledge because the laboratory activity cannot be designed for the students to participate according to their individual level of cognition and at a rhythm of learning at their own pace. The lab activity runs only through the logical process of scientific knowledge which is authorized objectively (Armstrong, 1903; Bruner, 1960; Roth, 1995).

The focus of studies on the school laboratory became subsidiary and secondary as far as the byproduct and the function of the laboratory experiment are only to be concerned, which is far from the fundamental questions related with revealing the educational aspect and undergoing mechanism beneath it. These trends in science education studies were reviewed (Han, 2004a), and showed that the laboratory experiments at school were only studied by the perspective of socialization and enculturation. When we retrospect that 'discovery' and 'inquiry' were the main topics of science education research on laboratory experiments and the rationales for the introduction of the laboratory into school systems, the situation described above proves that there has been a deep discrepancy between what they have asserted and what they have actually pursed.

Actually some attitudes which the teacher displayed, such as considering the verbal transmission of scientific facts or contents of textbooks as his major roles as a teacher and thinking that the students' participation in the experiment itself automatically contains educational meaning, were signs of misunderstanding and conceptional confusion in education. As described above, there were many activities lacking educational value regardless the enthusiasm the teacher invested in the students' experiment.

### 4. Overturning the Structure: The 'Educooperation' Context

Laboratory experiment activity can certainly be beneficial to science education if it is 'educationally' well structured(Schwab, 1962; Han, 2004a, 2004b). Generally speaking, in contrast with classroom classes, laboratory classes have more room for students to participate in the class more actively and the chances of educational interaction occurring between the teacher and the students are higher. However, it is also true that the teacher needs to control the students in order to prevent all sorts of problems related with safety and maintenance. Teacher needs to monitor the students and prevent them from being distracted by the physical environment of the laboratory, which is usually very different from a regular classroom. These kinds of teacher's roles are important for making the environment favorable to education, but they should be conceptually separated from their educational roles.

Whether an activity possesses the value of 'education' is not a matter restricted to the boundaries of the school, but a matter of its whole structure, which is composed of intrinsic elements induced from the endogenous principles of education(Chang, 2005; Han, 2004a, 2004b; Kim, J, 2000; Yang, 2005). The frame of a laboratory activity with educational value is composed of the internal elements of education itself, so to speak, the activities of the teacher and the students which follows the intrinsic rules of education(Han, 2004a, 2004b). However, the results of the laboratory class analysis did not seem to display this nature.

The whole structure of the class proceeded in a unidirectional way. The teacher was a sender, and the students were receivers of information. What has been 'overemphasized' in the previous research is

**Table 3**

*Comparison of the two contexts of a school laboratory activity*

| | Traditional Context | Educooperation Context |
|---|---|---|
| Purpose | very functional:<br>-enculturation to scientific community<br>-development of science<br>-obtaining general skills | educational experience as a form of life |
| The Pattern of Individual Activities | extrinsic-motivation and relying on external reinforcement | self-motivation and personal commitment |
| | absolute stands for knowledge | relative stands for knowledge |
| | following the given curriculum | arrangement of materials and activities depending on the stepwise progress of the students |
| | confirmation of results based on the objective facts | confirmation of results through self-transformation |
| Relation Between Teacher and Student | asymmetrical and unidirectional:<br>sender vs. receiver,<br>helper/assistant vs. major role | symmetrical and bidirectional:<br>descending educator<br>↔ ascending educator |
| Evaluation Criteria | the degree of achievement of the goal proposed by the given curriculum. | the degree of obeyance to the intrinsic principles of education |

adapting or becoming a member of science, science centered, or other purpose centered rather than education itself; however, a possibility for changing the structure was also noticeable.

Even though the students did not show fully their interests, the students' intrinsic motivation was observed when the level was properly tuned to their individual levels; however, the curiosity at their individual level was treated as noise. The intrinsic motivations of the teacher and the student were overlooked. Now it's time to put this issue high onto the stage of education research. The new structure can be summarized as follows in comparison with the traditional one.

## VI. Conclusion

In the world of science, the laboratory experiment is a form of life composed of multiple realities, which means it can be interpreted by various perspectives (Hacking, 1989; Galison, 1997; Lenoir, 1988; Pickering, 1992; Stuwer, 1975; Wheaton, 1983; Latour and Woolgar, 1986; Kohler, 1994). 'Educational perspective' can be one of these perspectives, of course. Interpretation of the laboratory experiment from the perspective of education is a matter of the conception of education, which is far beyond the physical boundaries of school. However, this perspective has yet to be pursued in the field of science education research.

This study theoretically highlights the educational aspect of laboratory activity, especially one in the school environment, and gives new value to it through providing an alternative viewpoint to science education. Unlike the laboratory activity of professional scientists, the school laboratory has somewhat different functions derived by 'schooling', which has lead to conceptual confusion in the field of science education. This study shows that this confusion can be clarified by introducing an autonomous perspective of education and proposes a new direction for the school laboratory to go.

To verify this hypothesis, this study analysed the structure of a laboratory experiment in a high school biology class based on ETE and tried to show that the educational aspect has been neglected and overlooked. Furthermore, a new model of school laboratory from the perspective of education was suggested. When the laboratory class is educationally structured, the whole structure of the laboratory experiment will change into educooperation.

In the educooperation model, the school laboratory has the value of providing an opportunity for the teacher and the students to interact as descending educator and ascending educator respectively with equivalent partnership. However, in order for this relationship to be realized at school, some conditions are pre-requisites, such as times for educational maturation, the ability of teachers to tune the level of students' activities according to their own level, and most of all, the perspectives on education of students, teachers, and every relevant person in the school environment.

The possibility of realizing this new model at school needs to be verified in the future because this study just shows how to restructure the laboratory experiment in school science from the perspective of education. However, instead of just waiting for the school environment to change in order to fit into this model, individuals definitely need to make ceaseless efforts in improving their own perspectives on education through 'meta-education'[2].

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2) 'Meta-education' is a theoretical term, which means the development of ability and perspective on education through participating in the educational process itself (Chang, 2005).

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