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# A case study on the formation and sharing process of science classroom norms

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**ABSTRACT**

The teaching and learning of science in school are influenced by various factors, including both individual factors, such as member beliefs, and social factors, such as the power structure of the class. To understand this complex context affected by various factors in schools, we investigated the formation and sharing process of science classroom norms in connection with these factors. By examining the developmental process of science classroom norms, we identified how the norms were realized, shared, and internalized among the members. We collected data through classroom observations and interviews focusing on two elementary science classrooms in Korea. From these data, factors influencing norm formation were extracted and developed as stories about norm establishment. The results indicate that every science classroom norm was established, shared, and internalized differently according to the values ingrained in the norms, the agent of norm formation, and the members' understanding about the norm itself. The desirable norms originating from values in science education, such as having an inquiring mind, were not established spontaneously by students, but were instead established through well-organized norm networks to encourage concrete practice. Educational implications were discussed in terms of the practice of school science inquiry, cultural studies, and value-oriented education.

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Science classroom norm; elementary school science; formation; sharing; internalization

## Introduction

Learning takes place through social interaction in a community (Lave & Wenger, 1991; Vygotsky, 1963). Emphasis on the social nature of learning has been stressed in science education for a long time, and educators in this field attempt to understand the sociocultural context as well as its effect on student learning (Lemke, 2001; Tobin, 2005). For example, science educators have focused on certain specific features of sociocultural context and its effects by looking at factors such as the social relationships between classroom members, the act of socially and culturally contextualized meaning-making through discourse analysis, and the science learning processes taking place in specific local cultures or contexts (Aikenhead, 1996; Lemke, 1990; Roth, 1995).

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In particular, learning in schools is more collective and social than any other kind of learning. School is a representative social institution and life inside the classroom is represented by the following three features: life as a member of a crowd, life as a potential recipient of praise or reproof, and the sharp difference in authority among members (Jackson, 1990). With these features, various sociocultural factors in schools have a strong effect on the behaviours of the members (Anderson, 1996; Schweingruber, Duschl, & Shouse, 2007). Thus, to understand learning phenomena in a school, it is essential to investigate the sociocultural contexts that impact both teachers and students.

Research on school science has also discussed the various issues concerning sociocultural factors faced in school settings. Past research has emphasized the complex interrelation between personal and social factors that teachers or students are faced with (Anderson, 1996; Saka, Southerland, & Brooks, 2009; Tobin, 2005). For example, Anderson (2002) argued that beliefs and values of teachers are critical factors for developing new reforms towards inquiry, but at the same time political and cultural factors in real classroom contexts should be considered as well. In the same vein, it has been reported that teaching practices are influenced by the sociocultural context faced by teachers as well as by their own beliefs (Saka et al., 2009; Tobin, 2005).

Along with the complicated relationship between individual and social factors in the practice of school science, we note the norms formed in science classrooms. For individual factors, the values and the beliefs of individual members are reflected in a group norm (Lemke, 1990; Yackel & Cobb, 1996). At the same time, for social factors the developmental processes of norms reflect the social relations and power structures in a group (Graham, 2002; Horne, 2001). In this sense, norms can be the connection that mediates between individual and social aspects of the classroom (Chang, 2016; Chang & Song, 2015; Lemke, 1990).

In consideration of the nature of norms in negotiating both individual and social factors, attention needs to be given to the development process of classroom norms. Group norms evolve continuously, and thus the process of developing norms can show the dynamic interactions and practices in a group (Graham, 2002). Nevertheless, few have discussed how norms are established and shared in their classrooms. This study attempts to examine the establishment process of classroom norms as important indicators reflecting both individual and social features.

Group norms formed in the classroom have been discussed in various areas of education such as classroom management and subject matter education (Driver, Newton, & Osborne, 2000; Schmuck & Schmuck, 1997). Exploring the features of classroom norms, many scholars have found that various norms coexist in classrooms (Boostrom, 1991; Yackel & Cobb, 1996). For instance, Yackel and Cobb (1996) categorized norms in mathematics classrooms into two types: social norms originating from beliefs about student roles and about the general nature of school life and socio-mathematical norms originating from mathematical beliefs. Similarly, science classroom norms were classified into norms for behaviour guidance, general academic norms, and scientific inquiry norms (Chang, 2016; Chang & Song, 2015). In addition, the social effect of classroom norms was reported in previous research. Lemke (1990) explored rules of classroom members and categorized them as strategies used for either attempting to control other members or for the management of classroom events. He argued that classroom rules are a mechanism of social control and reflect power, interests, various social contexts, and values in science classrooms.

On the contrary, some researchers concentrated on science-specific norms, also known as domain-specific norms, in classrooms (Becker et al., 2013; Driver et al., 2000). For example, Driver et al. (2000) argued the necessity of argumentation norms to develop students' ability to construct arguments. Becker et al. (2013) described the features and the impacts of socio-chemical norms in detail. The exploration of science-specific classroom norms is more closely related to the practices of argument, inquiry activities, and school science than general classroom norms. In this vein, the present study attempts to focus on science-specific classroom norms having an influence on inquiry-based activities in school science.

Finally, this study concentrates on the formation and sharing processes of science-specific classroom norms in an attempt to identify how each member's beliefs in an individual dimension are reflected in the formation of science classroom norms, how science classroom norms are shared and distributed among members, and how the members assimilate to the norms. These questions can be summarized by the following main questions: (1) How and by whom are science classroom norms formed? (2) How are science classroom norms shared or internalized among classroom members?



## Research context

### *The context*

South Korea has implemented a centralized science curriculum, especially at the elementary level, where government-authorized science textbooks and teacher's guidebooks based on this science curriculum are developed and used. Because of the authority of government-endorsed textbooks, most elementary school teachers tend to rely on the textbooks and the teacher's guidebooks as standards when they organize their science classes. The teacher's guidebooks provide a variety of information such as purposes, main concepts, and questions and answers, all of which are frequently used by elementary school teachers.

Science is taught in three 40-minute science lessons per week by homeroom teachers or by science subject teachers in Korean elementary schools. Homeroom teachers, who spend the most time with students in a classroom, are assigned to take care of the class as well as to teach many subjects including science. However, for later grades such as Grade 5 or 6, homeroom teachers have more responsibilities in dealing with guidance counselling than the lower grade homeroom teachers. Currently in Korea the government policy recommends that several subject teachers who teach just one subject area be placed in Grade 5 or 6 (instead of the main homeroom teachers) in order to help homeroom teachers concentrate on their class management and other tasks. As a result, the number of science subject teachers is increasing in elementary schools in Korea. However, there is actually no significant educational background difference between homeroom teachers and science subject teachers because they are both chosen only based on individual school conditions. This means that a science subject area teacher does not necessarily have more interest in, knowledge of, or experience with science than a homeroom teacher.

## The participants

The participants were two teachers and their respective classes in two elementary schools located in a metropolitan area in Korea. This study sought to explore the developing process of norms in science classrooms, so we selected Teachers A and B, who were determined to have higher than average confidence and enthusiasm for science teaching than elementary teachers.

Teacher A was a fifth-grade homeroom teacher who had 8 years of teaching experience. Having graduated with a Master's degree in elementary school science education, she had a wealth of science content knowledge, skills, and self-efficacy in science teaching. Her class, Class A, consisted of six groups of four students of both genders and mixed ability. Her school, School A, where Class A was taught, was ranked at a medium academic level in Korea. Students in Class A were generally outgoing in the classroom.

Teacher B was a doctoral student in science education and a science subject teacher. Even though he had four years of experience when we collected data, he had never taught science in the classroom before because he had been a homeroom teacher for the last three years, and other science teachers had always been assigned to teach science to his students. Because of this, even though he had good theoretical science content knowledge and pedagogical knowledge, he had relatively low practical knowledge, skills, and experience in science teaching. Class B also consisted of six groups of four students of both genders and mixed ability. School B was one of the schools that receives economic support from the Korean government's 'Education Welfare Priority Support Projects', and was at the lower academic level of schools in Korea. Most students in Class B were just reaching puberty and as such tended to be more conscious of their friends. For the most part, students in Class B were active with their friends during break time, but participated in their classes passively.

## Data collection

Focusing on these two cases, data were collected through classroom observations, student interviews, and teacher interviews. Because norms are established in a community through dynamic interactions among members (Graham, 2003), small-group interactions as well as whole classroom interactions were both audio and video recorded. During eight or nine lessons in the first month of the first semester, two focus groups in each lesson were selected in order of group number. As classroom norms were being established, three or four students gradually became leaders who played important roles in norm formations. Once these leaders emerged, the groups including these students were observed and video recorded. The researchers also conducted semi-structured interviews for classroom members in order to investigate student opinions about classroom norms, about the activities or the events that happened in the classrooms, and about the study analysis in general (member checking).

Group norms evolve constantly (Graham, 2003), so it is necessary to observe classes for a sufficient amount of time in order to identify the development process of classroom norms. Hence, in this study the researchers collected data for 20 science lessons throughout one semester. The beginning of the school term is a crucial period for the establishment of classroom norms (Schmuck & Schmuck, 1997). Thus, we observed and recorded every science lesson in March, the first month of the school term in Korea. In the succeeding months, two or three lessons per month from each chapter focusing on inquiry-based activities were observed and recorded. The topics for each of the 20 lessons can be found in Appendices 1 and 2.

## Data analysis

### Re-conceptualization of 'science classroom norms'

As a first step to analyse science classroom norms, researchers had to extract the normative behaviours of members from various classroom phenomena. To accomplish this, the meaning and attributes of classroom norms were identified through theoretical review. The concept of 'norms' has various meanings which differ according to the researchers' foci. The term has also been used along with similar concepts such as value, belief, and rule (Horne, 2001). These similar concepts have slightly different meanings at different levels. The concept of 'classroom norms' could be re-conceptualized clearly by comparing it with the concepts of 'value or belief' and 'rule' (Chang & Song, 2015), as shown in Figure 1.

First, norms and rules are distinguishable in various ways based on theoretical perspectives. There are two representative perspectives on the relation between norms and rules in sociology (Hechter & Opp, 2001). From the first perspective, norms are statements that govern group members' behaviours (Horne, 2001). This perspective focuses on the sense of duty shared among members. Thus, from this point of view, norms are considered more of a broad term which includes rules. On the other hand, from the second perspective, norms are distinguished from rules by external enforcement or by internalization (Horne, 2001). This means that rules are enforced by external sanctions, but norms are followed with intrinsic value internally.

This study sought to determine how normative behaviours are established and how they affect students' classroom participation in collective learning situations for science lessons in school. This focus of the study deals with the shared norms which class members try to follow together. We did not explore which norms are enforced with external sanctions and which norms are not. In this context, the first perspective described above was adopted, taking the broad meaning of norms to include rules.

Second, the relations between norms and values were verified as well. Group norms reflect pursuing values or beliefs of group members, because norms are established based on the

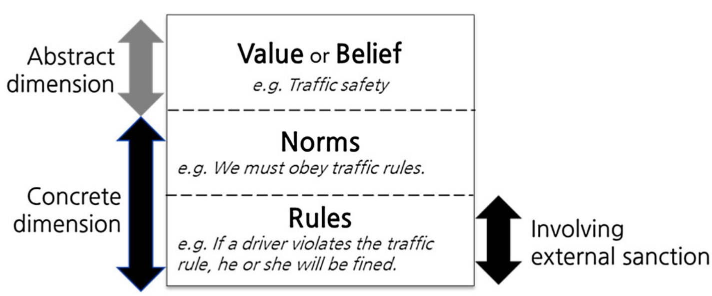


**Figure 1.** A comparison among values or beliefs, rules, and norms.

consensus of the members (Horne, 2001). In other words, within a group, pursuing values or beliefs in an abstract dimension could be realized through the enforcement of norms in a concrete dimension. At the same time, if members consider the specific norms as worthwhile, the norms could be internalized into the members' minds. These internalized norms become the values or beliefs of individuals. In this regard, the relations between norms and values are dialectical (Chang & Song, 2015). With these dialectical relations, this study attempts to investigate how values or beliefs of group members affect the formation and sharing process of group norms.

In conclusion, group norms are defined as having three essential features: actions, justifiability, and sharing (Chang & Song, 2015). First, norms always involve concrete actions. In other words, norms are described through the form of a certain action, while values remain abstract concepts. Second, every norm is value oriented, thus they have their own normative justifiability. Third, the normative behaviours should be shared with group members. If the specific normative behaviour remains only at the individual level, it cannot be a group norm. Based on this, science classroom norms could be defined as 'something shared among class members to make members act in a certain way with a sense of duty in science classrooms' (Chang & Song, 2015, p. 304).

### *Analysis on the formation and sharing process of 'science classroom norms'*

To analyse the formation and sharing processes of science classroom norms, the grounded theory suggested by Glaser and Strauss was modified and employed (1967). For *open coding*, two experts in science education looked into the emphasized ideas or the frequent stories that emerged in six science lessons (around 25% of the total observed and recorded), in the related interviews data. From these data, factors influencing norm formation in the classrooms were extracted such as norm itself and its related values or beliefs. Inter-rater reliability was estimated by calculating the percentage of agreement between the two experts. A level of agreement of 92% was obtained. All disagreements were resolved through discussion. For *axial coding*, the way in which the developing processes of norms in science classrooms are related to the members' values or beliefs was discussed. Focusing on the relationships among values or beliefs, norms, and rules, stories about the developmental process of each norm were developed. For *selective coding*, the stories were integrated and elaborated by examining materials from various sources such as video recordings, voice recordings, and interview transcriptions. Specifically, the researchers presented the stories of each norm in diagrammatic form in order to explain the developmental process of science classroom norms more clearly.

## Results

In this section, stories about the formation and sharing process of each classroom norm are presented. Focusing on two cases, each story of the creation of a science classroom norm is presented focusing on three things: (1) the key values or beliefs embedded in each norm, (2) the formation and realization process of each norm, and (3) the effect of each norm on student participation through internalization.

## Class A

### (Norm A-1) We should try to make our own interpretations of phenomena in inquiry activities

Teacher A believed that it was important for students to develop the habit of thinking about the reasons for phenomena on their own in order to have meaningful science investigations. Hence, she wanted students to think a lot with a 'scientifically inquiring' mind, but it was not easy. When asked how she wanted to teach science, she answered:

> Excerpt 1
> In science classes, I try to make students think about the reasons for phenomena. I always try to ask 'why is this happening?' in experiments. But it is hard because most students do not enjoy thinking or talking about the phenomena. So, I try to create a more appropriate atmosphere for students. (Teacher A, in the first interview)

This teacher's belief about scientifically inquiring minds was reflected in her actual science lessons. We observed that she called on her students to interpret the inquiry process on their own by asking 'why do you think so?' before and after inquiry activities. The following are from the researcher's field note, which was about 'which electric circuits make light bulbs brighter':

> Excerpt 2
> Teacher A asked the students to look at six electric circuits, three parallel circuits and three series circuits, which had light bulbs, predict which would be brighter, and write the reason for their expectation in their notebooks. The following were suggested by students.
>
> YH: The light bulbs in series circuits are brighter, because going straight is easier than changing directions.
> SC: The most important thing is the number of wires used in the circuits. The more wires are used in a circuit, the more energy will be gone. (Class A, in the field note on the 14th lesson)

As shown in Excerpt 2, Teacher A had students prepare a science notebook and asked them to write their own opinions and interpretations in the notebook for every science lesson. The teacher checked the students' science notebooks every week after a science lesson and provided feedback on the students' writing. In other words, students were able to keep thinking about phenomena through the related rules organized by Teacher A.

Teacher A established the opportunity for students to share their own interpretation with others as well as to interpret the phenomena. In Excerpt 3, she called on her students to talk about their prediction.

> Excerpt 3
> Teacher A: Let's predict which direction the moon appears to move across the sky. We could be wrong. It's OK! Please feel free to talk. SI?
> SI: From the west to the east.
> Teacher A: Why do you think so? Can you tell me the reason?
> SI: It's just a thought.

Teacher A: You just make random answers. You need reasons for your answer. AR?
AR: I think it would appear to move from east to west.
Teacher A: Why?
AR: Because the earth is spinning from west to east, and it has been observed that the moon moves across in the opposite direction.
Teacher A: OK. That's a good point. SC?
SC: It rises in the east and goes up to the sky and then goes down in the west.
Teacher A: Why?
SC: I saw it with my eyes! (Class A, in the 7th lesson)

In Excerpt 3, Teacher A emphasized that everyone could be wrong and that the important thing is to make interpretations based on appropriate reasons. In other words, the teacher tried to lighten the students' burden concerning right answers during discussions on their thoughts. Students were comfortably encouraged to give their own reasons to explain a phenomenon. Through these kinds of experiences, the enforcement of Norm A-1 became more stable and naturally accepted in Class A.

However, students perceived the appropriateness of norms at different levels. Some students had a deep understanding of why Teacher A emphasized that they should think their own thoughts, but others had no idea why she did that. In the interview Excerpt 4, students answered at various levels of understanding:

Excerpt 4
Researcher: Why did your teacher ask you, 'Why is this is happening?'
YC: Because … maybe … she didn't know about it?
JS: Because she wants for us to think ahead about the inquiry results. Then we can compare our thoughts with the actual results.
SC: Because … she wants to make us think a lot.
MJ: Well, it's just her style. (Class A, in the interviews after the 19th lesson)

In Excerpt 4, JS and SC understood exactly the intention of the teacher, while YC and MJ did not show that they did. The important thing is that students accepted the norm differently depending on their level of understanding of the appropriateness of the norm. Excerpt 5 shows this tendency.

Excerpt 5
(The students connected the fifth electric circuit using series connections.)
SC: The light is dim.
JS: I think I know why.
SC: Because there are many electric wires. It causes a shortage of electric energy.
MJ: Hey guys! Stop making noise! We have to hurry. (Class A, in the 14th lesson)

In this inquiry activity of Excerpt 5, JS and SC understood the necessity of Norm A-1 well and tried to interpret and discuss the phenomena on their own. However, MJ, who did not fully understand the necessity of the norm, considered the discourse between JS and SC as mere chatter. MJ was just interested in completing the activities as soon as possible. Finally, SC and JS fought with MJ because their interests veered in different directions. To sum up, different levels of understanding about the norm caused different acceptance levels of the norm and an imbalance of participation among the students. Here is another case that shows different acceptance levels of Norm A-1.

Excerpt 6
(The students discussed the results to find common features among three parallel circuits.)
SC: What are the common features of circuit numbers 4, 5, and 6?
MJ: [All of them are] parallel circuits.
JS: Parallel?
SC: What is that [term]? There could be a person who doesn't know that term. We have to focus on finding their features!
MJ: OK. They are connected with many wires.
YC: I'll skip.
JS: The positive poles of each battery are connected with the positive poles of the other batteries. (Class A, in the 15th lesson)

As can be seen in Excerpt 6, the four students accepted Norm A-1 to a different degree even though they were taught by the same teacher. The three acceptance levels of the norms were arranged as shown in Table 1. The first level is *pretending to follow*. YC made his own interpretation only when the teacher checked with him about it. A student such as YC at this level pretends to follow the norm as a political strategy in order to avoid being scolded by the teacher. The second level is *selective acceptance*. MJ did not follow the norm in the 14th lesson, but she followed it in the 15th lesson. In other words, a student at this level sometimes follows the norm but sometimes does not. The third level is *internalization*. This was observed frequently when JS and SC focused on their own interpretations in the inquiry activities. They valued making their own interpretations with inquiring minds and followed the norm spontaneously.

In conclusion, the developmental process of Norm A-1, 'We should try to make our own interpretations of phenomena in inquiry activities', can be summarized as shown in Figure 2. As a representative top-down type of norm, Norm A-1 was established based on the values and beliefs of the teacher. She also organized the related rules to support this norm. The norm was formed and shared with the whole class; however, the extent to which a student accepted the norm was different according to that student's understanding of the norm. Some students internalized the norm and the

**Table 1.** Three levels of acceptance of classroom norms.

| Levels | Description |
|---|---|
| Pretending to follow | Students at this level pretend to follow norms as a political strategy to avoid being scolded by the teacher, not considering the appropriateness of the norm |
| Selective acceptance | Students at this level follow norms selectively depending on the situation, even though they understand the appropriateness of the norm |
| Internalization | Students at this level understand the appropriateness of the norm deeply and follow it spontaneously. They accept the value and belief embedded in the norm |

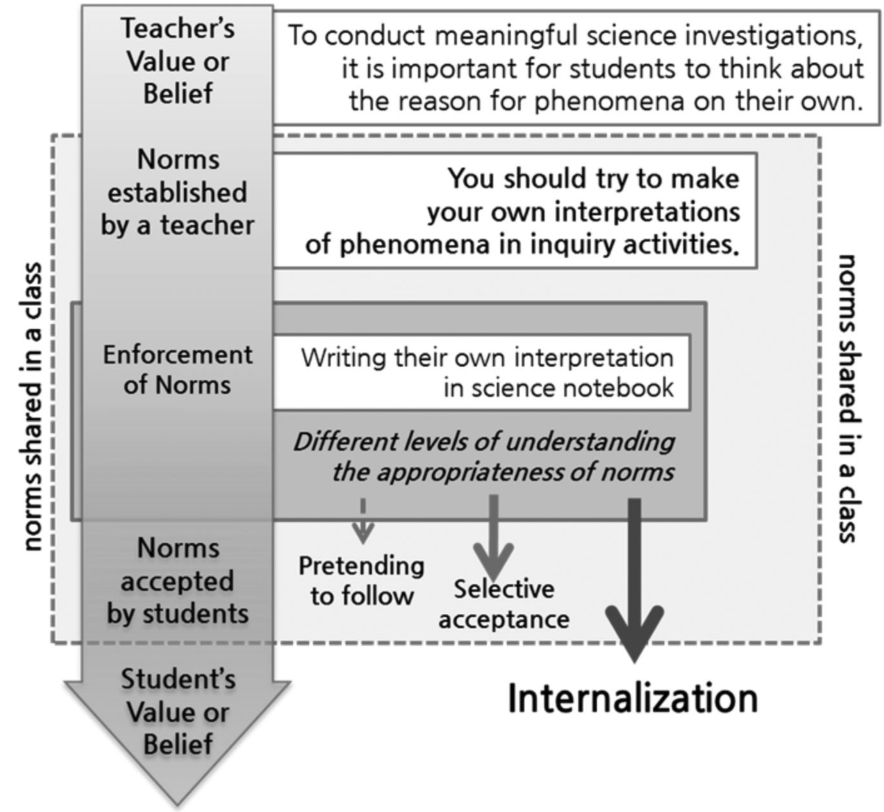


**Figure 2.** The process of formation and sharing Norm A-1.

core value embedded in the norm, but others only pretended to follow or accepted the norm selectively. These different responses caused an imbalance in student participation.

### *(Norm A-2) We should follow the normative standards suggested by the teacher to evaluate peers' interpretations in group discussions*

After making their own interpretations in most inquiry activities, students in Class A were asked to evaluate their interpretations with others through discussions with Teacher A. Students had opportunities for sharing and evaluating peers' thoughts. However, group discussions were designed not to construct science knowledge through social interactions, but to more effectively understand science knowledge. In various interviews, Teacher A did not ever mention the social construction of science knowledge or the nature of science knowledge. The following interview Excerpts 7 and 8 show her educational purpose during these group discussions:

> Excerpt 7
> Children like group activities. They enjoy talking with each other and solving questions together rather than solving questions alone. Thus, I often design group discussion in my lessons. (Teacher A, in the 5th interview)

Excerpt 8
I try to share students' thoughts with the whole class whether their thoughts are right or wrong. And then in the end I tell them the right answer. (Teacher A, in the 1st interview)

As shown in Excerpts 7 and 8, Teacher A designed group discussion in her lessons only because students prefer that type of learning. For this reason, the discussions in her science lessons were rather limited to the social construction of science knowledge. In other words, it was rarely observed that discussions developed into higher levels of argumentation, which include critical rebuttal or justification beyond simply evaluating peers' opinions. In many cases, students' interpretations were judged based on the normative standards established by the teacher's authority. In Excerpt 9, students were invited to describe the features of the earth after observing a picture from outer space. Teacher A then called the class together to share their findings and to evaluate peers' opinions.

Excerpt 9
Teacher A: Is there something you don't agree with [among the various findings]?
SY: It [the earth] isn't an oval but a round.
Teacher A: In this picture, it looks round. But strictly speaking, the earth is oval. But in this activity, it is OK to write that the earth is round … because we observed and extracted the features from this picture. Anything else?
MY: Humans live on the earth.
Teacher A: Humans live on the earth, but that is not what you observed. That's just the knowledge you already have. (Class A, in the 2nd lesson)

In Excerpt 9, the teacher asked the students to judge whether peers' interpretations were based on evidence or not. This judgement became the normative standard in this discussion of Excerpt 9 and students evaluated their peers' opinions using this normative standard.

However, sometimes the normative standards suggested by the teacher were inappropriate to enhance the level of discussions or inquiry. Teacher A even evaluated students' interpretations immediately. In Excerpt 10, the teacher called the whole class together to evaluate the inquiry results drawn up by group discussions. However, instead of establishing an opportunity for students to think, she gave them feedback instantly.

Excerpt 10
Teacher A: Let's talk about the common features of circuit numbers 4, 5, and 6 that you came up with as a result of your group discussions.
Group 1: The batteries in these circuits were connected in parallel.
Teacher A: Right. The batteries are connected in parallel. [She wrote this sentence on the blackboard.] Next?
Group 2: More electric wires were used in these circuits than the circuit numbers 1, 2, and 3. [These were series circuits.]
Teacher A: Ok … umm. Next? [She did not write it.] (Class A, in the 15th lesson)

In Excerpt 10, Teacher A responded to each group's findings differently depending on their correctness. The teacher gave positive feedback when the results were correct. On the contrary, she skipped over the incorrect results. For example, Group 2's answer related to the number of wires was ignored by the teacher without any mention. This pattern of interaction is similar to the Question–Answer–Evaluation pattern suggested by Lemke (Lemke, 1990). That is, even though students had a chance to make their own interpretations and share them in discussions, the discussions could not develop meaningful science investigations. Furthermore, in this case students' misconceptions remained unchanged by being ignored. In this activity, some students thought that too many electric wires in parallel circuits could use up the electric energy, which could make the bulb dim. The three parallel circuits in this activity actually have more wires than series circuits do. Even though the number of electric wires was focused on as a common feature by students in many groups, the teacher considered it an unimportant variable and ignored it. Excerpt 11 is part of a conversation during the closing process of the 15th lesson described above.

Excerpt 11

Teacher A: Let's check the common features of the circuit numbers 1, 2, and 3.
Students: Connecting with the different poles! The light is brighter!
Teacher A: Yes. And how many lines do they have?
Students: Two? Three?
Teacher A: What? The serial circuits are connected in just one way! How about parallel circuits? They are connected into two different ways. (Class A, in the 15th lesson)

In Excerpt 11, Teacher A used a vague term 'line', which meant 'way' to her; however, students interpreted 'line' as 'wire', so they answered the number of wires. However, the teacher did not recognize this. Thus students did not have any chance to correct their misconceptions.

In sum, Teacher A established normative standards to evaluate students' findings together based on her limited beliefs on science inquiry, science pedagogical knowledge, and discussion activities. We observed that her normative standards sometimes helped the development of scientific discussions, but in other cases interrupted discussions. Especially, it is notable that the normative standards suggested by the teacher's cognitive authority became the absolute criteria in constructing or negotiating science knowledge in classrooms. The teacher and the students were not equal cognitively; hence, the norms based on cognitive authority were considered and accepted by students as the only true way. Thus, as shown in Figure 3, these norms could have more immediate and bigger effects on students' inquiry practices.

## Class B

### (Norm B-1) Nevertheless, we should produce the correct answers

Most students in Class B believed that there is a correct answer in science. They also thought that they messed up if the experiment results came out differently from the content in the textbook. We observed that in every lesson, students copied down what

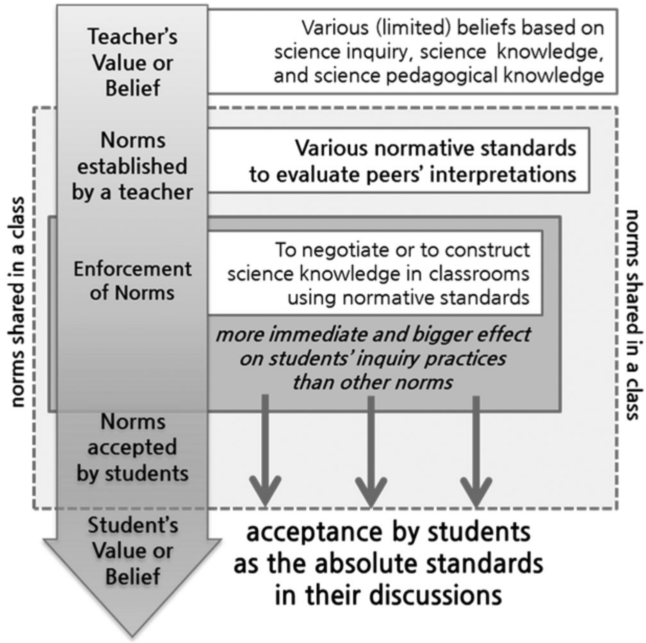


**Figure 3.** The process of formation and sharing Norm A-2.

Teacher B said or corrected their own answers rather than making their own interpretations. This tendency in Class B was in contrast to the features observed in Class A. Excerpt 12 showed this tendency

Excerpt 12
(After talking about the results of practical work with students, Teacher B called students to write the results in their textbooks.)

Teacher B: OK. Please write about the process … how we see the objects.

[Students copied down the content of the PowerPoint presentation made by the teacher.]

Teacher B: Oh, no. Please reorganize your own thoughts. Don't you like making your own answers? [The teacher closed the PowerPoint program to hide the answers.]
Students: No! Please don't do that!
Teacher B: You already know the answer. We already talked about that. Expressing with your own words is better than copying it down. (Class B, in the 11th lesson)

In Excerpt 12, Teacher B emphasized that students should express their thoughts using their own language but, nevertheless, students were resistant to changing their habits. These habits of students were so strong that the norm 'Nevertheless, we should produce the correct answers' was formed among them. They corrected or sometimes even falsified their actual results to produce the right answers. The following conversation in Excerpt 13 is about a lesson on the relationships between sun's altitude (10°, 45°, or 90°) and temperature. One group produced results which were different from what they already knew:

Excerpt 13

JH: The temperature is 25°C when the altitude is 10°, 27°C at 45°, and the temperature is 26°C at 90°.

CH: What? Is that right?

JH: Oh … maybe we screwed up. Why 26°C?

[After a while, Teacher B asked each group to tell the extent of temperature change.]

JH: [In a whispering tone] How should I say it?

CH: [In a whispering tone] How about 3, 4, and 5! …

[JH thought about it for a moment, and finally spoke.]

JH: The temperature change is 3°C at 10°, 4°C at 45°, and 5°C at 90°. (Class B, in the 13th lesson)

In Excerpt 13, strong beliefs about producing the right answers were shared among the students, which brought about the result manipulation. In this class, Teacher B explained that if the results are different from what we expect, it is important to check the control variables. Nevertheless, students did not take this instruction into account and still thought that they had ruined their work.

In sum, students established their own norm, 'We should produce the correct answers', based on their strong habits or beliefs. Their preoccupation with correct answers could not be altered easily. Finally, they copied down the right answers or corrected their answers and sometimes even manipulated their own results to match the information given in the textbook. These norms remained unchanged even though the teacher tried to persuade the

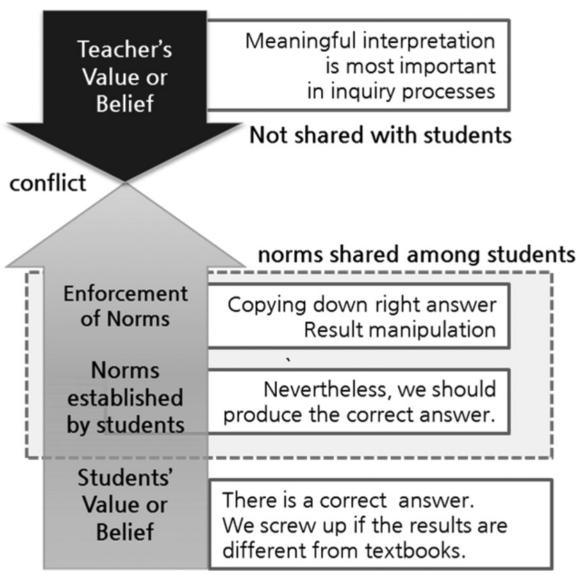


**Figure 4.** The process of formation and sharing Norm B-1.

students to interpret inquiry results in a meaningful way. In other words, the teacher's belief could not be shared with students and only remained in his mind, as shown in Figure 4.

### *(Norm B-2) We should not pollute the environment during experiments*

Before starting the chapter about acid–base reactions, Teacher B established a norm related to environmental ethics. This norm, based on the value of environmental protection or respecting life, was that students should not pollute the environment during experiments. Teacher B explained the reasons behind this norm and asked students to discard wastewater separately.

Excerpt 14

We should discard wastewater separately. If we discharge wastewater into the river, it will have negative effects on the creatures in the river in the same way that an acidic solution damages our skin. (Class B, in the 15th lesson)

The students fully agreed with the necessity of this norm and its values. Most of them responded to questions about reasons for following Norm B-2 as follows.

Excerpt 15

S1: We should of course comply with it because protecting the environment is important.

S2: We should reduce environmental harm because the environment and its creatures are precious. (Class B, in student interviews after the 16th lesson)

We also observed that after every experiment, students discarded wastewater regularly without any further directions. That is, students followed the norm consistently even though the teacher did not provide them any feedback. The following field observation note shows this tendency.

Excerpt 16

After experiments, Teacher B called the students to clean up the instruments they used. Students put wastewater in the discharging drum naturally, although the teacher didn't say any more about it. (Class B, in the field notes of the 16th lesson)

As seen in Excerpt 16, Norm B-2 became established in a stable way without regular feedback or direction. In conclusion, as shown in Figure 5, the reason that norm B-2 could be shared and worked out smoothly was that students were willing to accept the core values of the norm. This also led to voluntary participation in following it. In other words, if a value embedded in a certain norm has universal validity, the norm can be established stably in a group and fully internalized in group members' lives.

## Conclusions and implications

In this study, the way in which science classroom norms are formed and shared among classroom members was investigated through a case study of two classrooms. Each norm in the two classes was established differently. The norms reported here could be categorized into three types according to the features of the sharing process: teacher-initiated norms, teacher–student-negotiated norms, and students-initiated norms. Teacher-initiated norms are both established by a teacher and shared in an effective way. Norms of this type were

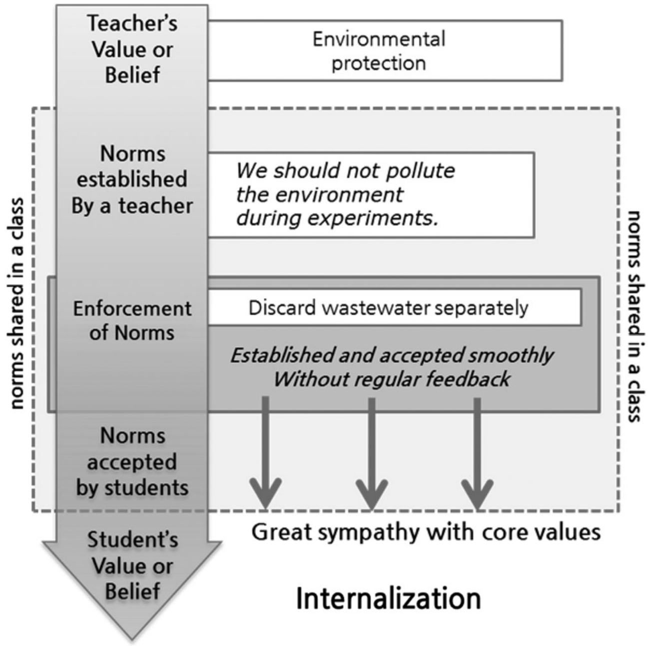


**Figure 5.** The process of formation and sharing Norm B-2.

based on either universal values such as environmental protection or the cognitive authority of the teacher. These norms came from reasonable values; for example, Norm B-2 was accepted quickly and created voluntary participation of students. Teacher–student-negotiated norms were suggested by a teacher, but were open to the possibility of various interpretations. Norms of this type were accepted and internalized at different levels, depending on students' levels of understanding of the norm. Different interpretations of the same norm caused an imbalance in classroom participation, as could be seen in the case of Norm A-1. Students-initiated norms were established by students. Norms of this type were not purposely designed for the class, but were instead inherent in students' deep-rooted beliefs or habits. These norms were observable only intermittently but tended not to easily change. For example, Norm B-1 originated from the students and remained unaltered throughout the semester, although the norm was in direct conflict with the teacher's belief.

When focusing on teachers' beliefs, we can interpret the three formation processes of science classroom norms reported in the above findings as three different processes in which teachers put their beliefs into their classroom practices. In this study, it was found that some teacher beliefs developed into science classroom norms and had an effect on students' inquiry activities (Norms A-1, A-2, and B-2); however, other beliefs did not (Norm B-1). These findings correspond with the mixed findings about the influence of teachers' beliefs on their classroom practices in previous studies. For example, some researchers have argued that teachers' beliefs strongly affect their classroom practices (Magnusson, Krajcik, & Borko, 1999), while others have insisted that teachers' beliefs, interacting with various factors, have no direct influence on their practices (Roehrig & Luft, 2004). One of the main causes of 'the convoluted relationships' between teachers' beliefs and actions could be the complexity of classrooms, including multidimensional interactions with various factors such as member beliefs, parental expectations on teaching and learning, and social relations (Kim & Tan, 2011; Roehrig & Luft, 2004). In this vein, this study identified how each value or belief, interacting with several factors in classrooms, emerged as a science classroom norm.

In light of the findings in previous research and in this study, we also suggested the formation conditions of science classroom norms to foster meaningful inquiry in schools. The four conditions of science classroom norms that encourage inquiry were developed as follows. First, desirable science classroom norms originate from inquiry-oriented values such as having an inquiring mind or thinking critically. For example, Norm A-1 originated from the teacher's values about inquiring minds and created an inquisitive atmosphere in which students could make their own interpretations actively. Second, for meaningful science inquiry practice, it is important that the teacher-led norms based on the teacher's authority are established as structural devices to develop students' values or potential related to science inquiry. In the two classes, it was not found that students established norms to support science inquiry on their own. This result indicates that desirable norms could be established through structural devices to encourage concrete practice. Third, it is necessary that students are given an opportunity to empathize with the values of the norms. In our findings, students were willing to accept and internalize science classroom norms if they thought that the core values of the norms were worthwhile. As for the norms enforced without persuasion or sympathy, students did not internalize but pretended to follow them. Fourth, students need to practise the norm repeatedly within well-organized norm networks because their strong habits originating from non-inquiry values or beliefs could be changed by a well-organized norm network. Strong beliefs about right answers on the part of students in Class B had negative effects on inquiry practices and could not be changed easily. On the other hand, students in Class A focused more on their own interpretations than on right answers, even though both teachers emphasized the inquiry process. The difference between Class A and Class B was whether rules to support inquiry were established systemically and implemented repeatedly or not. Teacher B emphasized the importance of inquiry process just through words, but Teacher A established several rules to support Norm A-1, 'We should make our own interpretations', and enacted them repeatedly. These findings indicate that internal change in a student's mind could be influenced not only by emphasizing with words, but also by involving repeated practice with the norm.

The view of science education as a process of enculturation has been developed and stressed over the decades (Aikenhead, 1996; Lemke, 2001). The process of enculturation involves the acquisition of science culture or school science culture through language, values, beliefs, and norms (Aikenhead, 1996). Thus, internalization of norms can be interpreted as one aspect of enculturation (Chang, 2016). Specifically, in this study, several types of sharing and internalization processes of norms were discussed. Among them, there were cases which promoted internalization as well as cases which disturbed internalization. In this way, these findings have great implications for science education in terms of the process of enculturation. However, only two classroom cases with fifth- and sixth-grade students were examined to analyse the sharing and internalization process of norms in this study. The sharing and internalization process of norms could be different depending on the developmental levels of students. For example, middle school students in the adolescent period will respond differently to certain classroom norms. The findings of this study cannot lead to the conclusion that all students will act in a similar way. Thus, further study is necessary to explore additional cases of formation and sharing of norms in middle school or lower grade elementary classrooms.

According to Einstein (1954, p. 63),

> Education is that which remains, if one has forgotten everything he learned in school … . I want to oppose the idea that the school has to teach directly that special knowledge and those accomplishments which one has to use later directly in life.

It could be argued that meaningful values or beliefs will remain in students' minds even though they forget everything else in their school lives. Considering his remarks, to inculcate one good value could be more difficult, but at the same time, more effective, than to teach a certain body of knowledge or skill. We discovered in this study as well that science classroom norms can be good indicators for figuring out which values have been formed and are being shared in actual science classrooms. From this value-oriented perspective, there is a need for more research in science education to explore possible frameworks for establishing science classroom norms based on desirable values in school science.



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No potential conflict of interest was reported by the authors.

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## Appendix 1. Lesson topics in Class A

| Chapter | Topics |
|---|---|
| Orientation | What is science? What is science inquiry? |
| 1. Earth and moon | Let's make the photo puzzles of the earth and of the moon |
| | What do you think of the figure of the earth? |
| | What do you think of the figure of the moon? |
| | Why is there day and night? |
| | Why does it look like the sun is going around the earth? |
| | Which direction does the moon appear to move across the sky? |
| | How do the moon phases occur throughout the month? |
| | Why are there phases of the moon? |
| | Let's observe the surface of the moon through an astronomical telescope |
| | Chapter evaluation |
| 2. Electric circuits | How do a battery and a light bulb combine to produce light in the bulb? |
| | How does the brightness of a bulb change according to how two batteries are connected? (I) |
| | How does the brightness of a bulb change according to how two batteries are connected? (II) |
| | Let's draw an electrical circuit in a simple way |
| 3. Structures of plants and their functions | What are the structures of roots and their functions? |
| | How does water pass up the stem? |
| | What are the structures of leaves? |
| 4. World of microscopic creatures | Let's see the world of microscopic creatures |
| | Let's raise the microscopic creatures |

## Appendix 2. Lesson topics in Class B

| Chapter | Topics |
|---|---|
| Orientation | What is science? What is science inquiry? |
| Light | Let's play with light |
| | How does an object look when you look at the object through a pinhole camera? |
| | How does light travel after reflecting from the mirror? |
| | How does light travel at the interface between water and air? |
| | How does an object look when you look at the object through a lens? |
| | How do we see an object? |
| | Chapter evaluation |
| | Let's make a camera and observe an object through the camera |
| 3. Season changes | How is sun's altitude related to shadow length and to temperature? |
| | Why does temperature change during the seasons? |
| | How are both sunrise and sunset time and temperature related to the seasons? |
| 4. Ecology and environment | How do organisms interact with each other in ecology? |
| | How does environmental pollution affect organisms? |
| 2. Acids and bases | What are the properties of aqueous solutions of acids and bases? |
| | How will the properties of aqueous solutions change when two aqueous solutions of acids and of bases are mixed together? |
| 5. Magnetic field | What causes the phenomenon around an electric wire with current passing through it? |
| | What will happen to the needle of a compass when near ring-shaped wire? |