Theory and Research for Developing Learning Systems, 2 : 35-47, 2016
Research Initiative for Developing Learning Systems (RIDLS)

Research into Development of Beliefs about the Goals and Purposes of Science Teaching:
Analysis of Life Stories of Five Experienced Science Teachers

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This research, through analysis of five experienced science teachers' life stories, was done to further evaluate prior research into beliefs of science teachers. Furthermore, it attempts to clarify the development of beliefs about the goals and purposes of science teaching to show how beliefs about the goals and purposes of science teaching develop through pre- and in-service teacher education/training, the value of this, and suggestions towards the realization of this. First, an overall concept of beliefs about the goals and purposes of science teaching is clarified by further evaluation of prior research. Next, life story was utilized as a research methodology for the clarification of belief development, and an interview survey was planned and conducted based on this methodology. The stories gained were analyzed, and the facts that various experiences, whether in or out of school, have an influence to clarify beliefs about the goals and purposes of science teaching, that there are cases where experiences outside of school can provide motivation for adding new concepts to one's beliefs about the goals and purposes of science teaching, and that beliefs about the goals and purposes of science teaching that were held at the time of becoming a science teacher do not change throughout a professional career, were all made clear. Based on the above results, the development throughout one's professional career concerning beliefs about the goals and purposes of science teaching is perceived as part of a science teacher's consecutive professional learning, which happens in and out of school. Pre-service teacher education should make a vital role as giving an opportunity for developing beliefs about goals and purposes of science teaching. Suggestions were gained for how to realize development of beliefs about the goals and purposes of science teaching through pre- and in-service teacher education, as well as the value of this.

Key Words: Science Teachers, Beliefs, Continuing Professional Development, Life Story, Goals and Purposes of Science Teaching

1. Introduction

Beliefs of sciences teachers are said to be one of the concepts at the core of a continuing professional development (Gilbert, 2010). Beliefs have an influence in various sides of classroom practice, for example, the acquisition and interpretation of knowledge, interpretation of the curriculum, lesson planning practice, and evaluations (Jones & Leagon, 2014; Bryan, 2013). When discussing Japan, beliefs of science teachers include their various concepts such as views on (science) education, (science) teaching, learning, and science. One example of prior research into beliefs of Japanese science teachers is the views towards science and classroom practices of elementary and lower-secondary school science teachers (Shimizu, 2002).

It is important to mention that outside of Japan, some research dealing with the science teaching orientations, which be shaped by three subcategories (Friedrichsen et al., 2011): "beliefs about the goals and purposes of science teaching," "science teaching and learning," and "the nature of science", has come forth (for example, Campbell et al., 2014; Cobern et al., 2014; Avraamidou, 2013). In Campbell et al. (2014), a before and after survey of the development [1] of science teaching orientations over one year of professional development was conducted, and it was made clear that beliefs about the goals and purposes of science teaching play a central role in the development of that science teaching orientations. Although clarifying the development of science teacher beliefs about the goals and purposes is one vital research topic, research into the beliefs of Japanese science teachers has mainly focused on their beliefs about science teaching and learning, and the nature of science. There is not a large body of research into beliefs about the goals and purposes of science teaching.

In this study, an outline of prior research into beliefs of science teachers will be given first, and a concept of beliefs about the goals and purposes of science teaching will be clarified. Subsequently, there will be a discussion of the research methodology that was applied to clarify the development of beliefs of science teachers. The results gained from the survey based on this methodology are organized from the viewpoints of 1) beliefs that science teachers hold towards the goals and purposes and 2) the process of how those beliefs develop. Finally, based on these, the value of developing beliefs about the goals and purposes of science teaching through pre- and in-service teacher education are established, and suggestions towards realizing this are reached.

2. Theoretical Framework

2-1 Beliefs about Goals and Purposes of Science Teaching

In Friedrichsen et al. (2011), prior research is further evaluated and beliefs that shape the science teaching orientations are classified into three categories, as can be seen in Table 1. Here, beliefs about the goals and purposes of science teaching are placed into one of the categories of science teaching orientations and are beliefs on the general goal and function of science education.

Table 1: Classification of Beliefs that Shape Science Teaching Orientations

Beliefs about Goals and Purposes of Science Teaching
Conceptions about the goals or functions of science education in general, for example, divided into learning science, learning to do science, and learning about science, or teaching science for intellectual development, or for individual fulfillment, or for socioeconomic benefit.
Beliefs about Science Teaching and Learning
Conceptions of science teaching and learning, including beliefs about the role of the teacher, the learner, how students learn science, and how to teach it in ways that make science attractive and comprehensible.
Beliefs about the Nature of Science
Conceptions about the nature of science, sometimes divided into ontological beliefs, that is, beliefs about the status of reality or the existence of scientific objects and epistemological beliefs, about issues such as "what counts as knowledge, how this is produced and warranted or justified."

Source: Created based on: Friedrichsen, P., van Driel, J. H., & Abell, S. K. (2011). Taking a closer look at science teaching orientations. *Science Education*, *95*, 370-371.

Also, Campbell et al. (2014) subdivided beliefs about the goals and purposes of science teaching based on Roberts' (2007) classification of scientific literacy into Vision I and Vision II. According to Roberts (2007), Vision

I is the view that science education fulfills the function of teaching knowledge of the products of the natural sciences as well as its process while Vision II is the view that science education fulfills the function of teaching citizens from childhood how to solve specific situations that they may happen to encounter in the future.

In this way, beliefs about the goals and purposes of science teaching can also be perceived as beliefs about the goals of the school subject "science", which is placed at the highest level of the hierarchy of goals for science education.

2-2 Definition of Beliefs

Here, we will define beliefs as used in this study. Although over twenty years of research in science education has given attention to teachers' beliefs, there is still no universal definition of beliefs. At the root of this is the philosophical question of how knowledge and beliefs are different (Jones & Leagon, 2014; Bryan, 2012; Pajares, 1992). Dewey (1922), for example, states that the history of human learning is a chronicle that includes the emotional parts of human learning and refers to the indivisibility of past humans' knowledge and beliefs, as their knowledge was limited to the extent of their past beliefs.

On the other hand, research into the differentiation of knowledge and beliefs in science education has also yielded a differentiation that has attained a fixed consensus. Although Jones & Leagon (2014) states that both knowledge and beliefs originate from experience, it does recognize a fixed distinction between knowledge as a mainly cognitive structure, and beliefs consist of both a cognitive and an emotional structure. Fletcher & Luft (2011) differentiate knowledge from beliefs stating that there is no necessary condition that beliefs are factual.

Based on these arguments, a science teacher's beliefs in this study will be treated as "a science teacher's individual thoughts based on experience and prior knowledge."

2-3 Beliefs, Classroom Practice, and Professional Growth

Although a consensus has been reached that belief is a concept that influences every aspect of a science teacher's classroom practices, the positioning of beliefs within a science teacher's classroom practices differs by researcher.

Jones & Leagon (2014) are devising a model that shows the association among a science teacher's knowledge, beliefs, and their classroom practices. Concepts inherent to the science teacher are divided into four domains: "Instructional Task or Problem," "Planning and Goal Setting," "Lesson Design," and "Evaluation." The domain of "Evaluation" mediates the others, and they all have a mutual influence on one another. Classroom practices are determined in part by the science teacher's perceptive filter and external concepts of socio-cultural context. The results of the teacher's classroom practices also work in reverse to influence their inherent conceptual beliefs. Beliefs of science teachers are, together with their concepts of knowledge, seen as one important factor in how a science teacher clarifies "Instructional Task or Problem." The definition does not end by stating where each factor starts from but rather says that science teachers conduct their classroom practices while cycling through these factors.

Gess-Newsome (2015), however, is designing a model that shows the relation between a science teacher's professional knowledge, skills, classroom practices, and includes their PCK (Pedagogical Content Knowledge). A science teacher's belief is seen as something that mediates between their classroom practices and professional learnning, similar to an amplifier or a filter. This model is recursive and fluid, and it leads a science teacher to the professional knowledge, skills, and classroom practices that they need to improve student outcomes.

Regarding the position of a science teacher's beliefs, Jones & Leagon (2014) position beliefs (together with knowledge) as one of the factors in "Instructional Task or Problem" that are regulated on the basis of a science

teacher's instructional planning and strategy. Although Gess-Newsome (2015) argued that beliefs are fluid, they are positioned as an amp or filter that mediates between a science teacher's professional knowledge and their classroom practices. Although there are some discrepancies between the positioning of a science teacher's beliefs within their classroom practices, a science teacher's beliefs are undoubtedly seen as one of the vital factors in the process of giving and learning classroom practices.

By contrast, a teacher's beliefs are (together with a teacher's knowledge) also seen as one factor in the execution of a teacher's classroom practice, as well as how teachers accomplish professional growth through reflection (Clark & Hollingsworth, 2002). Similarly, science teachers are perceived in both Jones and Leagon (2014) and Gess-Newsome (2015) as achieving growth by cyclically being influenced by each factor within the model, which all have a mutual effect on each other. In other words, a science teacher's beliefs not only influence their classroom practices but also are factors that play a vital role in achieving professional growth.

3. Discussion of Methodology Applied to the Survey

3-1 Outline of the Main Research Used for the Interview

A science teacher's belief system is complicated; therefore, most of the research mainly takes a qualitative research approach. An interview is one of the most popular qualitative research methods (Jones & Carter, 2007). In research that utilizes data gained through interviews, there are oral history, life course, life history, and life story, which are all broadly classified depending on the focus of the research (Yamada, 2005).

Oral history is defined as "verbal records of public figures, by the specialists, for the people (Mikuriya, 2002, p.5)." Therefore, the main objective of oral history is to gather historical accounts by interviewing public figures related to the functions of the government, politics, the economy, diplomacy, and more.

Life course is defined as "the multiple tracks throughout a career divided into ages, namely the societal pattern that is seen in the interval and sequence of what one accomplishes throughout opportunities and periods of transition (Inagaki, 1988, p.2)." Therefore, the main objective is to generalize the lives of specific age groups.

Life history utilizes documents and other things aside from the oral data gained through the interview to create the historical context necessary for comprehending the story (Goodson & Sikes, 2001). The main objective is to close in on the historical facts of an individual's life (Yamada, 2000).

Life story pays attention to the way in which a person speaks about their own experiences, and the main objective is to hone in on the experiential facts (Yamada, 2000) by interpreting the meaning of the experiences the person has had (Sakurai, 2012).

Beliefs are concepts that "many people are not self-aware of, going about their day to day life without realizing what kind of beliefs they hold (Akita, 2000, p.194)." Based on these distinguishing features of beliefs, this study does not seek to hone in on historical facts on the development of beliefs from a life history point of view but rather to employ the life story point of view to hone in on the experiential facts in the development of beliefs and pay attention to "the meaning of how a person organizes their own experiences when speaking of them to other people (Yamada, 2005, p.192)." In other words, the study takes the standpoint of "even if what is being told is not historically accurate or remembered correctly, it is still thought of as the reality of that person's 'story or tale' (Yamada, 2005, p.196)."

3-2 Life Story Methodology

There are cases where a "life story" refers to primary source and cases where it refers to methodology. A life story that is primary source is defined as a person chooses to tell about the life he or she has lived, told as completely and honestly as possible (Atkinson, 1998, p.8). Therefore, life story highlights the most important aspects of a

person's life. By contrast, life story used as research methodologies are defined as "a qualitative investigative method that takes stories which are based on experience and seeks to read as holistic of an individual's life, their world, as well as changes and phases in society and culture (Sakurai, 2012, p.6)."

The important thing when conducting life story research is that attention must be paid not only to the content of the story but also to the way the person talks, as this provides an indication as to the significance of what is being discussed in the story (Sakurai, 2012). Stories in an interview are organized into three aspects (Sakurai, 2012). The display of the progression of past accomplishments within the limits of an interviewee's unique experience is the taleworlds. Outside the framework of experience, the story's significance index, indicated through the mutual effect that both the interviewee and interviewer cause in each other, is the storyrealms. Greetings and so on are conversation.

In this study, stories are analyzed from the viewpoint of how science teachers organize their stories when speaking on the development of their beliefs while keeping in mind the differences between the different aspects of a story.

4. Outline of the Interview

4-1 Framework of the Interview

Based on the methodology of Atkinson (1998), Sakurai (2012), and Sakurai & Kobayashi (2005), a semi-structured interview was created, the full course being three interviews. The time anticipated for each interview was about an hour and a half, and Table 2 shows the established theme as well as the main questions.

Interviewees were informed in advance by email that the intent of the interview was to learn "What experiences have influenced your thoughts on science education, and how have these thoughts changed?" Also, approximately one week prior to each interview, the interview's theme and main questions were emailed to the interviewees. At the interview location, the interviewee spoke freely about what they wanted to, based on the main questions. In the event that the interviewee was not motivated to speak of their own accord, the interviewer would ask the main questions in sequence. When the stories became abstract, the interviewer would request more specifics by asking additional questions.

Table 2: The Main Questions and Theme of Each Interview

1st Interview: Recalling Life Memories
1. How did you view school science in your elementary, lower-, and upper-secondary school years? 2. Which university (and faculty) did you choose? What were the reasons you wished to attend that university? 3. What did you study specifically during your university years? 4. Did experiences as a student teacher have a positive influence on you? Or did it have a negative influence on you? 5. When did you ultimately decide to become a teacher? 6. Please tell us about the progression after becoming a teacher; what kind of schools did you work at, what grades did you teach, what other official responsibilities did you have, and what difficulties or hardships arose within your educational practice? 7. If you went to graduate school, why did you decide to go there?
2nd Interview:Experience as a Science Teacher
1. What kinds of goals did you have for normal science lessons? What kinds of lessons did you create to achieve those goals, and what kinds of teaching did you apply? How did you reflect your own lessons? Please elaborate for each school that you worked at. 2. Throughout the process of your work as a science teacher, what influenced your growth as a science teacher? For example: encounters, activities, books, educational practices, training, graduate school training, or something from fields outside of your formal occupation as a teacher, such as regional or family influences. If there are multiple influences, then please tell us about all of them.
3rd Interview: Beliefs on Science Education
1. What do you think science is? 2. What do you think school science is? 3. What way do you think school science should be taught? 4. What is your image of a good science teacher? 5. What kinds of abilities does a good science teacher need? 6. How and where is one able to acquire such abilities?

4-2 Selection of Interviewees

When selecting interviewees, a total of five experienced science teachers were chosen. Four of them held administrative positions as teacher supervisors, and exhibited professional growth as teachers and ascended through the job ranks. One of them continually grew as professionals, and voluntarily acquiring doctoral degrees. A short CV for each interviewee is shown in Table 3.

Table 3: Interviewee CVs

Teacher A	Worked for 38 years in public junior high schools (20 of those in administrative position), now retired.
Teacher B	Worked for 31 years in public high schools (12 of those in administrative position), currently the principal of a public high school.
Teacher C	Worked for 8 years in a public high school, then 30 years in a high school affiliated with a national university (held the position of vice principal), then 3 years at the research institute for higher education, currently retired.
Teacher D	Worked for thirty-five years in a public junior high school, now retired. After retiring, has acquired a doctorate (in education) while continuing to work as a part time lecturer, but only in the mornings.
Teacher E	After working at company, worked for 35 years in a public junior high school (11 of those in administrative position), currently the principal of a public junior high school.

4-3 Interview Times and Dates

It was considered important that the interviewees be able to speak freely; therefore, there is a large disparity in the actual times of the interviews. The actual times and dates on which interviews were conducted is shown in Table 4.

Table 4: Actual Interview Times and Dates

Teacher A	2/10, 2/19, 2/25/2015, Approximately 4 and a half hours in total.
Teacher B	1/31, 2/20, 3/9/2015, Approximately 9 hours in total.
Teacher C	3/5, 3/10, 3/17/2015, Approximately 4 hours in total.
Teacher D	9/18, 10/2, 10/23/2015, Approximately 4 and a half hours in total.
Teacher E	10/7, 10/21, 10/30/2015, Approximately 4 and a half hours in total.

4-4 Analysis of the Survey Results

The acquired stories were written out, and they were segmented by a change in speaker, or when the speaker shifted to a different subject.

As no uniform analytical method for life story has been developed, in addition to basing the study on life story methodology, the specific analytical method of SCAT (Steps for Coding and Theorization: Otani, 2008, 2011) was utilized. SCAT is an analytical method that describes storylines by coding from 1) to 4): 1) what words and phrases within the data should be given attention, 2) words and phrases from outside the data for rephrasing those important items, 3) words and phrases that explain those important items, 4) themes and conceptual constructs that arises from 1), 2), and 3). At the end, themes and conceptual constructs weave into storylines. When considering what data in 1) is noteworthy, the differences between the taleworlds and storyrealms were always kept in mind. Experiences within the storyrealms related to beliefs about goals or purposes of science teaching, Meanings were given to experiences within the taleworlds, or in the event that the interviewee was speaking on the beliefs they currently hold towards the goals of science teaching, all of these were indicated in 1) as noteworthy data items that should be paid attention.

5. Survey Results

Here, the storylines gained through the previously described analysis are quoted, and what each storyline says about the development of beliefs about the goals and purposes of science teaching is arranged according to each of the five experienced teachers.

5-1 The Case of Teacher A

Teacher A held the beliefs about the goals and purposes of science teaching are to "cause students to have interest in the theories of the familiar natural phenomena," and to "make students understand the fact-based theories of familiar natural phenomena."

Teacher A's beliefs about the goals and purposes of science teaching were held from the time Teacher A became a science teacher, as can be interpreted from this storyline: "while studying physics in upper-secondary school, I came to have an interest in the theories of the natural phenomena around me as they were expressed in simple numerical formulas. (…) From the time I started teaching, I utilized OHP to make it easier for the children to achieve the goal of science teaching, which is understanding the theories of familiar natural phenomena." Other than that, an "argument I had with friends during university" before becoming a science teacher also had an influence on Teacher A's beliefs about the goals or

purposes of science teaching.

After this, Teacher A's beliefs about the goals and purposes of science teaching were clarified throughout Teacher A's professional career, as can be interpreted from this storyline about researching teaching materials which Teacher A had trouble teaching: "while reading technical books related to what the students were studying, I learned there are theories to natural phenomena aside from physics (for example, weather phenomena). This experience led me to have a deep interest in fields outside of physics. (…) My beliefs about the goals or purposes of science teaching became clear." Other than that, "student reactions" and "observing experienced science teachers' lessons" also clarified Teacher A's beliefs about the goals and purposes of science teaching.

5-2 The Case of Teacher B

Teacher B held the belief about goals and purposes of science teaching is to "make students acquire a scientific way of thinking the world, which are basic requirements whether they become scientific experts or not."

From the time Teacher B became a teacher, Teacher B held the belief that this fundamental way of thinking the world was the goals and purposes of science teaching, as can be interpreted from this storyline: "while studying for exams, I truly felt I was starting to develop my own scientific way of thinking the world (which is the basis of understanding science) in my former teacher's class (Chemistry)." Other than that, "the realization that I'd forgotten knowledge that I'd learned as a young child" before becoming a science teacher, as well as "the experience of feeling that I had learned my own way of thinking the world during my former teacher's lessons (elementary school science and Japanese history)," and "a developmental psychology course during university, an introductory course on the study of science education, and experience as a student teacher" all had an influence on Teacher B's beliefs about the goals and purposes of science teaching.

After that, at Teacher B's first school which was evening upper-secondary school, Teacher B took advice from a consultant teacher that added to Teacher B's beliefs about the goals and purposes of science teaching the concept that even students who will not become scientific experts need the foundation of a scientific way of thinking the world, as can be interpreted from this storyline: "I was asked what kind of lesson I wanted to teach these students, some of whom will become scientific experts and some of whom will not. (…) Even in my evening upper-secondary school, where most of the students would not become experts, I felt the necessity of ensuring students acquire a fundamental scientific way of thinking that would be useful to them in their work and daily lives."

Teacher B's beliefs about the goals and purposes of science teaching were further clarified through Teacher B's professional career, as can be interpreted from this storyline about student scores that happened when Teacher B was posted at a newly established school that was meant to be a college prep school and another school which had been a college prep school for quite some time: "there were many teachers who thought to increase student scholarly knowledge by providing information and making them do drills. (…) In that kind of school culture, my classroom practices were carried out after I had considered what kind of lesson I should create to make my students acquire that fundamental scientific way of thinking that they would need whether they became scientific experts or not. As a result, my own student's scores were always higher than those of other science teachers." Aside from that, "questions and answers with the students at the evening upper-secondary school," "student scores," "meetings with a person from the Ministry of Education," "research during graduate school," and "analysis of university entrance examination" all further clarified Teacher B's beliefs about goals and purposes of science teaching.

5-3 The Case of Teacher C

Teacher C held the belief about goals and purposes of science teaching was to "properly pass down science, which is what mankind has used to build up its own

culture," but experiences which had an influence on the development of this belief were not recognized. However, Teacher C did speak to the effect that it is possible the beliefs about the goals and purposes of science teaching that Teacher C held when becoming a teacher gradually came into clarity throughout Teacher C's professional career.

5-4 The Case of Teacher D

Teacher D held the belief about goals and purposes of science teaching are to "pass on a feeling of elation towards science as beginning of producers of science," and "cause students to have an interest in technology as consumers of science."

From the time Teacher D became a science teacher, Teacher D held the belief about goals and purposes of science teaching was to pass on a feeling of elation towards science as beginning of producers of science, as can be interpreted from this storyline about research during Teacher D's time at a graduate school of engineering: "the feeling of elation one has whenever an experiment yields results is a true experience as a science producer. (…) What I first thought was that I wanted to pass on to the students was the feeling of elation towards science that I experienced during my time at the graduate school of engineering."

After that, this belief came into higher clarity throughout Teacher D's professional career, as can be interpreted from this storyline about student careers: "among the children who I taught to actually perform science through scientific research, there are some children who became scientific experts. This affirmed my belief about goals and purposes of science teaching was to pass on a feeling of elation towards science as beginning of producers of science." Other than that, "conversations with my Brazilian friend" also clarified Teacher D's belief about goals and purposes of science teaching.

Meanwhile, encountering certain teaching materials also led Teacher D to add a new concept to Teacher D's belief that one goal of science teaching was to make students have an interest in technology as consumers of science, as can be interpreted from this storyline about research at a graduate school of education: "when I was using the internet to research ESD, I stumbled upon *Twenty First Century Science* teaching materials from the U.K., which taught knowledge peripheral to science. (…) I remember being shocked and thinking, 'is this also school science?' With this experience as motivation, I came to hold the belief about goals and purposes of science teaching was to cause students to have an interest in technology as consumers of science."

5-5 The Case of Teacher E

Teacher E held the belief about goals and purposes of science teaching was to "teach all children the universally necessary problem-solving ability by way of dealing with natural phenomena."

Teacher E held this belief about goals and purposes of science teaching from the time Teacher E became a science teacher, as can be interpreted from this storyline about their job at company: "There were absolutely no work opportunities that would allow me to use the professional knowledge that I had learned at university. (…) Thinking that I could also apply the strategies of how to deal with research was useful to my work at company. This experience influenced my belief about goals and purposes of science teaching is not necessarily to teach students what to learn but rather to instill in them other abilities which will be useful for them when they enter society." Other than that, before becoming a science teacher, "science lessons during my junior high school days" also had an influence on Teacher E's beliefs about the goals and purposes of science teaching.

After that, Teacher E's beliefs about the goals and purposes of science teaching came into higher clarity throughout Teacher E's professional career, as can be interpreted by this storyline about the culture of the school that was Teacher E's second school: "until my second school posting, my belief about goals and purposes of science teaching was to nourish students' problem-solving

ability by thinking and talking through them, based on knowledge they already had. But at this second school, there was a culture of nourishing this problem-solving ability through every school subject." Other than that, "student reactions" also clarified Teacher E's beliefs about the goals and purposes of science teaching.

6. Discussion: Reflection on Results

6-1 Distinctive Features in the Development of Each Teacher's Beliefs

The results gained will be considered based on Roberts' (2007) classification of scientific literacy into Vision I and Vision II. Table 5 shows the development of these five experienced science teachers' beliefs about the goals and purposes of science teaching. Beliefs that they had held since they became a science teacher are marked with a "✓," beliefs that they had come to hold since the middle of their professional careers are marked as "Partial," and beliefs that they had never held are marked with an "X."

Table 5: Classification of the Five Science Teacher's Beliefs

Interviewee	Vision I	Vision II
Teacher A	✓	X
Teacher B	✓	Partial
Teacher C	✓	X
Teacher D	✓	Partial
Teacher E	X	✓

In this study, Teachers A, B, C, and D held beliefs about the goals and purposes of science teaching that fall under Vision I, and Teacher E held beliefs that fall under Vision II. Also, whichever beliefs the teachers held on goals and purposes of science teaching when they became science teachers were clarified throughout their professional careers. It can be thought that various experiences both in and out of school, for example, student reactions and outcomes, and meetings with other experienced science teachers, led to the affirmation of the teacher beliefs about the goals and purposes of science teaching.

Meanwhile, experiences out of school, for example, the advice that Teacher B received from a consultant teacher immediately after he became a teacher, and Teacher D's research experience in a graduate school of education during the mid-stage of her professional career, were the cause of them adding Vision II beliefs onto the Vision I beliefs that they already held.

6-2 Development of Beliefs through Consecutive Learning

Sato (2015) indicates that the fields of teacher learning and growing are arranged concentrically from inside to outside of school as follows: self-reflection on their own classroom practices, advice from colleagues at the same school, advice from principals and vice principals, educational research through on-the-job-training, and training at university and lectures from university professors. Sato (2015) also indicates that the function of the fields of teacher learning and growing become weak by spacing from inside of school.

Based on these notions, there will be an attempt to reframe the perception of the results this study gained related to the development of beliefs about the goals and purposes of science teaching from the viewpoint of teacher learning. In this study, experiences that clarified an individual's beliefs about the goals and purposes of science teaching came about both inside and outside of school. On the other hand, development that led to the addition of new concepts to individual beliefs about the goals and purposes of science teaching came from experiences outside of school. These points do not suggest that out of experiences from inside or outside of school, one has a stronger or weaker function than the other of developing beliefs about the goals and purposes of science teaching. Rather, it suggests that teachers' beliefs about the goals and purposes of science teaching are developed through consecutive learning both in and out of school.

6-3 Pre-service Teacher Education for Constructing Beliefs

In this study on the development of science teachers' beliefs about the goals and purposes of science teaching, the results that deserve special attention are the results showing that even if new concepts are added, concepts that are held when one becomes a science teacher continue to be held throughout the teacher's professional career. In the Campbell et al. (2014) survey, out of the eight science teachers who were surveyed before and after one year of professional development, seven of these science teachers continued to hold their Vision I beliefs while the other added Vision II beliefs onto the Vision I beliefs that he/she already held. Therefore, even if new concepts are added to beliefs about the goals and purposes of science teaching, development does not cause one to repudiate their pre-existing conceptions.

In other words, if one holds beliefs about the goals and purposes of science teaching when they become a science teacher, these beliefs maintain vital meaning as a concept that continually influences their day to day classroom practices and their professional growth. This suggests that, in addition to the concepts that it is difficult to change the beliefs that a teacher (Pajares, 1992; Kagan, 1992), in-service teachers with established beliefs are difficult to change their beliefs (Crawford, 2007), and pre-service teachers are easy to change (Luft & Roehrig, 2007), pre-service teacher education should make a vital role as giving an opportunity for developing beliefs about goals of science teaching.

7. Conclusion

Based on the experiential facts of five experienced science teachers, it became clear in this study that various experiences both inside and outside of school have the influence of clarifying a science teacher's beliefs about the goals and purposes of science teaching, that new concepts are sometimes added to these beliefs in the midst of professional career, and that the beliefs a science teacher holds when they become a teacher do not change over the course of their professional career. From these, the development of beliefs about the goals and purposes of science teaching throughout a teacher's professional career can be perceived as part of the science teacher's consecutive learning both inside and outside of school. Pre-service teacher education should make a vital role as giving an opportunity for developing beliefs about goals or purposes of science teaching. Suggestions were gained for how to realize development of beliefs about the goals and purposes of science teaching through pre- and in-service teacher education, as well as the value of this.

Although this study was not able to sufficiently discuss it, much of the prior research indicates that the experience of actually learning in a classroom has a strong influence on a teacher's beliefs (for example, Wong & Luft, 2015; Crawford, 2007; Luft & Roehrig, 2007; Eick & Reed, 2002; Tsai, 2002; Pajares, 1992; Lortie, 1975), just as three out of the five experienced science teachers who were interviewed for this study said that their learning experience during their elementary, lower-, and upper-secondary school years had an influence on their beliefs. Based on this point, clarifying the main factors in the formation of beliefs about the goals and purposes of science teaching held by students as they enter the pre-service teacher education is an urgent topic. Additionally, the revised perception of the development of beliefs from historical facts based on the continual interviews, discussion of other cases that contain quantitative survey, and discussion from the viewpoint that other science teachers' beliefs about teaching and learning and the nature of science have a mutual effect on each other, may be beneficial for creating more effective continuing professional development.

Acknowledgements

We would like to express our heartfelt gratitude to the five teachers who cooperated positively with us all throughout the lengthy interviews.

Note

1. Although *"hattatsu"* has been accepted as an established translation for the term "development," the word in Japanese tends to emphasize the meaning that the word has of explaining where one has made achievements. In English, the word 'develop' has a wide range of meanings. Japanese uses "*kaihatsu"* to describe potential, *"seichou"* to describe slow, natural growth, *"kaika"* to describe the growth of species, and *"tenkai"* to describe the development of images and diagrams. Just like a photograph is "developed" to reveal a previously invisible image, the phenomenon of the way the hidden negative image is seen depends on external influences. In this paper, the word *"hattatsu"* [development] is used to include this wide range of meanings. Yamada, Yoko (2011). "Hattatsu" to "Hattatsu Dankai" wo tou: syougai hattatsu to narathivu ron no shiten kara *(Reconsidering* "*Development*" *and* "*Developmental Stage*" *from the Perspectives of Lifespan Development and Narrative Theory)* [in Japanese with English abstract]. *The Japanese Journal of Developmental Psychology, 22*(4), 418-427.

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This article translated into Japanese is published in the journal *Gakushu Shisutemu Kenkyu*, Vol.3.