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A Science Teacher's Teaching Moves about Low and High Achieving Students: A Belief System Approach

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ABSTRACT

Closing the science achievement gap between low achieving (LA) and high achieving (HA) students has become an important part of educational policies, particularly in Turkey. Bearing this in mind, the purpose of the present study is to reveal a science teacher's teaching moves about LA and HA students and the pedagogical belief system behind these moves. This single case study relates to one science teacher (Mehmet), who performed explicit teaching moves. In order to determine the moves being used with LA and HA students, Mehmet is asked to write questions that he often uses in his lessons and explain the moves that he has applied during the questioning and solution phases. In addition, semi-structured interviews regarding teaching motivation, science teaching motivation, science teaching practices and beliefs about LA and HA students are conducted so as to reveal the belief-oriented background of these moves. The results show that the teaching moves varying according to the achievement differences is a complex phenomenon. Mehmet changes the structure of his scaffolding, his scientific practices and classroom technologies according to the achievement differences. He produces these teaching moves using a nested structure in which he contextualizes his teaching strategies in is daily science teaching practices.

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INTRODUCTION

The achievement gap among the students in schools, in different classroom and the students in the same classroom is among the subjects that has been given importance by teachers, researchers and policy makers for many years. The United States of America, for example, has implemented a reform named No Child Left Behind (NCLB) (2001) in order to close the achievement gap and provide quality education and create equal opportunities for every student. In Turkey, the Primary Education Program (PEP) has been initiated in order to provide equal, qualified education for all students focusing in particular on. The purpose of PEP was to educate students who do not meet the requirements of the Turkish and Mathematics curriculum in previous school years (PEP, 2018).

In the case of science education, the achievement gap is particularly alarming considering the goals and projects of developed and developing countries. PISA (Program for International Student Assessment) results, for example, showed that almost 20% of students in the Organization for Economic Cooperation and Development (OECD) countries showed a performance below the Level 2, the basic level of competence in science. These students generally confuse the main features of scientific research, apply incorrect scientific knowledge and confuse personal beliefs with scientific facts when making judgements (OECD, 2018).

Researchers agree that the reasons for the science achievement gap, are the considerable effect of science achievement acquired in early years, on achievement in later years (Morgan et al., 2016). When students are observed from the first stage of education to the middle school stage, the achievement gap between LA and HA in science increases. This is based on several pedagogical factors such as the type of alma mater and the quality of science teaching in the schools (Acar, 2018). The science teachers play a central role in these factors because some of their 'teaching moves' (i.e., iterative changes in classroom activities for making science meaningful for all students) and pedagogical belief set behind these moves exacerbate the science achievement gap. Researchers agree that the most important factor affecting teachers' in-class practices is their pedagogical beliefs (Fives & Buehl, 2012; Fives & Gill, 2015; Hayes, 2010; Kilinc et al., 2014; Pajares, 1992). Kilinc et al. (2017) argue that teacher epistemologies, beliefs about student learning and teaching efficacy are the central beliefs within the teachers' pedagogical belief systems and the teachers heuristically consult these beliefs when they make daily decisions on what to ask, how to react or whether it is necessary to conduct a particular teaching moves.

In terms of achievement differences, existing research (e.g., Zohar et al., 2001) shows that many science teachers possess problematic beliefs about how to undertake effective moves relevant for HA as opposed to LA students. Many teachers do not believe LA students to be capable of achieving higher-order learning goals (Raes et al., 2014; Zohar et al., 2001). It is considered that LA students generally lack metacognitive skills (e.g., collaborative planning, monitoring and reflection) (Yang et al., 2016, 2020). The data, for example, show teachers that seek to place greater emphasis on higher order thinking skills in classrooms with HA students in comparison to those with LA students (Page, 1990; Raudenbush et al., 1993; Zohar et. al., 2001). In one study, Raudenbush et al. (1993) determine the beliefs of science teachers (303 middle-school teachers) about higher order thinking and whether they emphasize these thinking activities in classrooms with differing levels of student achievement. It is found that while science teachers believe that HA students are able to accomplish many complex learning tasks in mathematics and science, they also think that LA students are able to complete complex learning tasks at a relatively less demanding basic level. In another study, it is observed that some science teachers asked far more difficult questions to HA students than to LA students (Zohar et al., 2001). The reason for the difference in these moves is the belief that instructional activities at a lower cognitive level were more appropriate for LA students. Almost half the science teachers in the study state that the most suitable method for LA students is the "transmission of knowledge". In addition, it is stated in the literature that traditional science teaching approaches, such as transmission of knowledge and reading textbooks for enhancing memory, are generally applied to LA students (Juuti et al., 2010; Kouso et al., 2018).

In another study (Torff, 2006), an assessment and evaluation instrument, related to Critical Thinking Belief Appraisal, was applied to 194 middle-school teachers. The results showed that expert science teachers expressed saw higher order thinking activities more suitable for HA students than LA students. In addition, Even and Kvatinsky (2009) observed the teaching methods of two mathematics teachers in two different classrooms including one with HA students and one with LA students. The researchers stated that the teachers followed different methods in each class when teaching the same subject. For example, they applied a method based on a ‘mechanistic answer finding’ approach in the LA classroom, whereby students almost never talked, while the teacher was explaining and asking questions. In contrast, students in the HA classroom were encouraged to get involved in the learning process by implementing an ‘understanding based’ method. They were asked to reconsider and examine their own and other students’ responses. Furthermore, it was observed that the teachers did not grant the same time to LA students to present their own solutions as they did in the HA classes and teachers generally answered their own questions in LA classes. In another study, Lokan et al. (2003) analyzed the data collected in Australia as part of a TIMSS Video Study. They concluded that teachers encouraged HA students to suggest alternative solution methods more than LA students. In a study focusing on how LA students were identified and the characteristics of the supplemental support provided to them, the teachers in the sample stated that they used a simplistic approach to help students succeed and that they provided easier versions of the assignments or teaching materials than they did for HA students (Jönsson, 2018). In addition, in another research findings teachers in the sample stated that more challenging learning tasks should be given to HA students (Barbier et al., 2022).

Some researchers argue that exceptional teachers may gain high student achievement even in low-achieving schools (Felch et al., 2010; Marzano et al., 2001). Of importance here is the activities or beliefs these teachers exhibit. Schmid (2018) have studied the activities and beliefs of teachers in low-achieving schools that consistently lead to high student achievement. His findings show that all three teachers who participated this research believe that all students can and do learn and this belief has a significant impact on student achievement. Teachers in this study repeat over and over until all students understand. Teachers in this study believe that the appropriate instruction is crucial for student success. The teachers believe that they need to continuously learn new teaching strategies through professional development for LA students and that if they provide appropriate instruction to them, LA students are able to succeed.

As can be seen, even if there are some positive exceptions, the existence of achievement difference may be exacerbated by the teacher moves and the beliefs behind them. Considering limited research on the moves about LA and HA students above, we believed that it is important to deeply investigate these moves which science teachers use and their pedagogical belief systems behind them. This is particularly important in terms of improving the academic success level of students with different achievement status, closing the achievement gap and allowing every student to benefit from educational resources to the same degree. Taken together, the aim of the present study is to determine a science teacher (Mehmet)’s teaching moves about LA and HA students and uncover the pedagogical belief system behind these moves. The following research questions are put forward:

- What teaching moves about LA and HA students did Mehmet perform in his science teaching?
- What was the nature of Mehmet’s pedagogical belief system about LA and HA students?
- Which of Mehmet’s pedagogical beliefs were responsible for his teaching moves about LA and HA students?

METHOD

Research Design

A holistic single-case study design is used in this interpretive research. According to Yin (2014), case studies are the research strategies that elaborately examine a current concept, or event within its own real-life context and are applied especially when the borders between the facts and its environment are unclear. Yin (2014) has suggested that single-case studies can be used in exposure of something which is previously unknown. In this study, a real concept (teaching moves) is extensively examined in a natural setting (Lincoln & Guba, 1985) and the moves about LA and HA students, the belief systems and the relationships between them that are unknown due to limited research is investigated (Creswell, 2012; Yin, 2014).

Research Sample

Since the snowball purposive sampling method provides data-rich cases for in-depth study (Patton, 2002), it is chosen for this study being applicable to determine which teachers undertake differing achievement levels into consideration. Accordingly, a middle school in Turkey is selected using a convenience sampling procedures in the 2016-2017 academic year. Permission for access is granted to the lessons of two science teachers (Hasan and Elif) in order to conduct the observations. An in-class science teaching observation form (Ross et al., 2004) is used during the observations. Several notes were taken about the teaching practices of teachers (e.g., questioning, feedback, and teaching materials utilised). In addition, the average grade of the class in the school science examination is consulted and the students attaining a lower grade than the average are categorized as LA, while those with a higher than average grade are categorized HA. This categorization is shared with the teachers and their approvals obtained.

After four-week (16 classroom hours) of classroom observations, it was concluded that Hasan and Elif implemented the same standard teaching strategies in all classes and did not differ in their teaching move regarding the achievement differences. At this stage, three science teachers (Aslı, Mehmet and Seda) in another school, were selected according to convenience procedures, to be included in the research process. The science lessons of these teachers were observed within same class and different classes in terms of students with different achievement levels. Using the same science teaching observation form (Ross et al., 2004) and after four-weeks of classroom observations (16 classroom hours for each teacher), only Mehmet used specific teaching moves according to whether he was teaching LA and HA students. For example, he asked superficial questions to LAs, whereas for HA student the questions were much more indepth. In addition, he utilized specific examples requiring high-level computations for HA students, which was not the case for LA students. Based on this Mehmet was selected to participate in single case study it being believed that he not only seemed to benefit from a range of teaching moves about achievement differences, but also potnetially possessed a rich belief set backing these moves.

In order to uncover Mehmet's teaching moves for students with different achievement levels, a thinking-aloud interview was conducted with him. In the interview, Mehmet was asked to write three questions that he used in order to teach basic science concepts and mechanisms. For this question topics were selected with the help of an experienced science teacher and a science educator. These topics were 'lifting force', 'states of substance and heat' and 'cell division and genetics'. Mehmet was asked to write one question for each of these topics and to explain how to ask this question and organize how to solve it for LA and for HA students. For ascertaining the pedagogical belief system backing these teaching moves, four semi-structured interviews were held related to 'teaching motivation', 'science teaching motivation', 'science teaching practices' and 'achievement differences in science classrooms'.

These interviews were conducted and recorded in different weeks and took about one hour for each. The voice recording equipment was used during the interviews. Before conducting all interviews, Mehmet was informed about ethical procedures and about the fact that he could leave the study whenever he wanted. In addition, the interview questions and procedures were confirmed by an ethical committee within one of the Turkish universities.

Research Instruments and Processes

Following five interview forms (IFs) were used in the present study. First form was used in order to reveal the teaching moves about LA and HA students, whereas remaining four were used to reveal the pedagogical belief system backing the teaching moves. All of the interviews were guided by three science educators in terms of validity and the forms were transcribed into text as indicated in the **Appendix.**

Interview 1. Teaching Moves-Thinking Aloud

This form included questions inviting Mehmet to write three different questions about the topics 'lifting force', 'states of substance and heat' and 'cell division and genetics' that he used during his science teaching for 8th grade students. In addition, the form included further questions asking Mehmet to conduct teaching moves for LA and HA students in his questioning, explanations and problem solving stages.

Interview 2. Teaching Motivation

This form included nine questions intended to determine Mehmet's beliefs about teaching motivation. In addition, factors influencing his selection of teaching as a career and his perceptions about the teaching profession, such as its demanding nature, social status and financial gains were asked. The studies by Sonmez (2015) and Kilinc et al. (2013) were used in the preparation of this form.

Interview 3. Science Teaching Motivation

This form consisted of eight questions about science teaching efficacy and achievement-oriented goals by Mehmet. The studies of Georgiou et al. (2002) and Sonmez (2015) were used in the preparation of this form.

Interview 4. Science Teaching Practices

This form included eleven questions about the nature of Mehmet's teaching practices. The questions were related to constructivist approaches, inquiry-based science teaching and process-oriented assessment-evaluation approaches. Rosenfeld and Rosenfeld (2006) and Sonmez's (2015) studies were used in the preparation of this form.

Interview 5. Achievement Differences in Science Classrooms

This form included three questions. Mehmet was asked to state the reasons for the achievement differences in the science classrooms, the characteristics of the LA and HA students and his teaching moves about LA and HA students.

Data Analysis

Grounded theory were utilized in the data analysis. Grounded theory is a method of systematically gathering and analyzing data and discovering new phenomena. Constant comparative analysis is one of the important features of this approach. Data collection and data analysis were carried out simultaneously (Glaser & Strauss, 1967).

In the grounded theory, coding is done for the purpose of conceptualizing the data by analyzing and to define the patterns or events in the data (Kuş, 2006). The analysis of the data obtained from the interviews consists of three stages: open coding, axial coding and selective coding. In open coding stage the data is reading and ideas or concepts that are considered important are determined by codes consisting of one or more words. In axial coding stage, categories are associated with subcategories and this relationship is tested based on data. In other words, which concepts are more important are decided and presented in a certain order. The selective coding stage, it is the process of selecting a category as the core category and associating all other categories with that core category. The core category represents the central fact about the studied situation. In this stege, final arrangements are made for the explanation of the investigated phenomenon. Finally, the research report is written by including the details of the subject and processes. In addition, some examples and quotes from the participants are included (Christensen et al., 2011).

A data set was constituted by making transcriptions of all interviews prior to the data analysis. The interview transcriptions were read separately by two authors. This made detecting the patterns easier. Memos were made and words were underlined to identify possible codes and categories. The analysis of the data obtained from the interviews consists of four phases open coding, axial coding, selective coding and model development (Kilinc et al., 2017; Strauss & Corbin, 1998).

Open coding, axial coding, selective coding stages were used for responding the first two research questions (i.e., 1. What teaching moves about LA and HA students did Mehmet perform in his science teaching? and 2. What was the nature of Mehmet's pedagogical belief system about LA and HA students?), whereas all stages were used for responding to the last research question (i.e., 3. Which pedagogical beliefs in Mehmet's pedagogical belief system were responsible for his teaching moves about LA and HA students?).

Through open coding phase of the analysis, the data obtained as a result of the interviews with Mehmet were read many times and coded by the researcher. The codes were written on paper directly next to the data. Those with similar meanings in different parts of the data were also named with the same code. In this way, the data in different parts of the data set and related to each other in terms of meaning were brought together. The codes were produced according to the meaning that emerges directly from the data. These codes were helped researchers identify categories. Conceptually similar beliefs were grouped into categories and quotations representing these categories were noted.

Axial coding requires an in-depth analysis of a category in order to uncover interactions and relationships with other categories, subcategories, and properties (Strauss & Corbin, 2002). In axial coding, the belief categories determined in open coding were then associated with subcategories and supported with quotes from Mehmet and also this relationship was tested based on data. With selective coding, a belief category was selected as the core category and all other categories were associated with this core category. Because both the teaching moves and Mehmet's pedagogical belief system were based on self-report data, the belief-oriented categorical system was used for uncovering the moves and belief system.

At the end of this categorical stage (i.e., at fourth stage), matches were made between the beliefs representing the moves and pedagogical belief system using the belief coherences (Kilinc et al., 2017) existing in the utterances. By displaying these matches with the lines, a visual model was produced, exhibiting possible relationships between the moves and the pedagogical belief system.

Trustworthiness

The methods suggested by Lincoln and Guba (1985) were used in this research to ensure trustworthiness. A longitudinal research design was planned in the field for procuring the internal validity (credibility) of research. The observations lasted approximately five months (32 weeks) and observations were conducted in each teacher's (total five science teachers) lessons for at least two hours per week. In this process, a bond of trust was established between the first author and the teachers. In addition, data triangulation and researcher triangulation were used to ensure the findings and comments were trustworthy. Peer debriefing was performed in the scheduling of all stages and data analysis. It was detected that there was an 80% compatibility between the belief categories and model building obtained by the first author and peer researcher (second author), after which repeated discussions were held until the compatibility rate increased to 100%. In addition, purposive sampling and extensive descriptions were used for the external validity (transferability). Within the scope of the research, the factors, such as data collection tools, data analysis and selection of Mehmet were explained in detail. In addition, direct quotations were made from Mehmet's opinions. In addition, two science educators, specialized in the field of science education, provided as an external audit at every stage of the research in order to ensure consistency.

RESULTS

Figure 1 represents the main results of the present study. The model has been formed by coding data according to suggestions of Strauss and Corbin (1998).This visual model not only shows the teaching moves (Research question 1) and Mehmet's pedagogical belief system (Research question 2), but also displays the relationships between them (Research question 3). In the following section, the results for each Research question are presented.

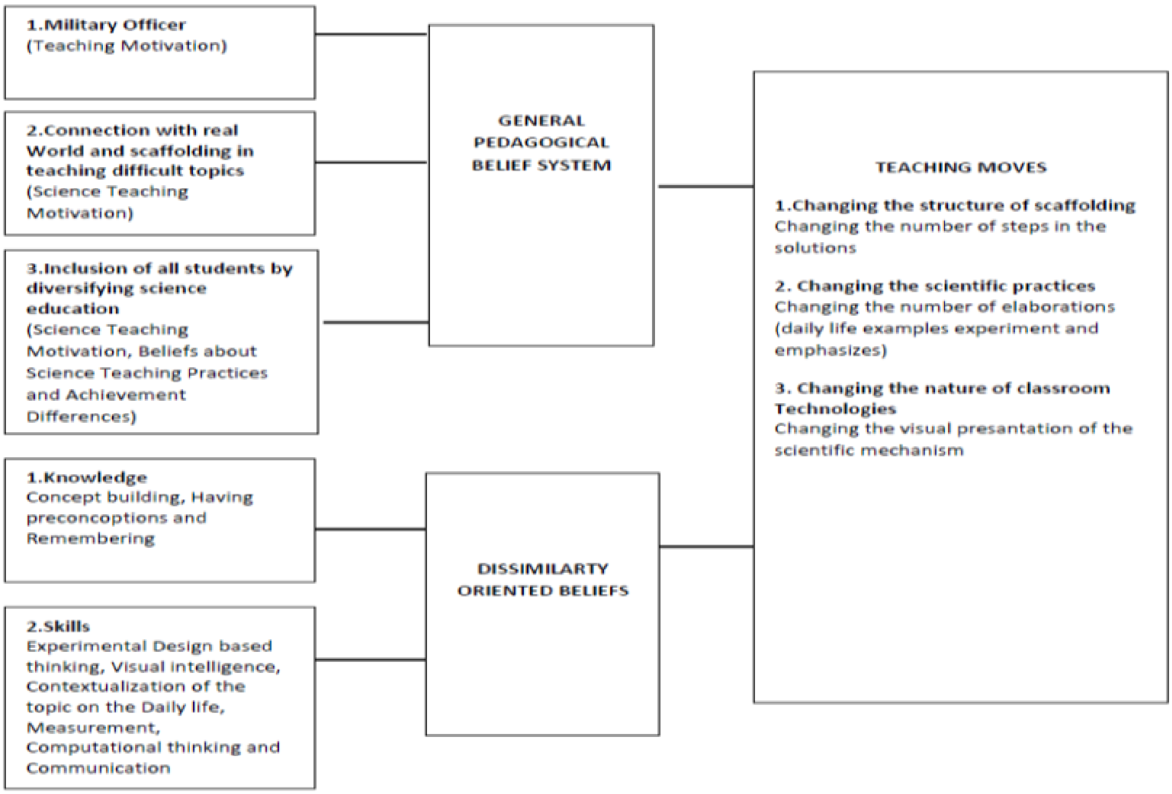

Figure 1. *The Model indicating the relations between the pedagogical belief system and the teaching moves performed by Mehmet regarding LA and HA students**

**Due to the bidirectional relationships, only lines were used for representing the relationships.*

Mehmet's Teaching Moves About LA and HA Students

Mehmet was asked to write one common question for each of the following subjects: (1) 'lifting force', (2) 'states of substance and heat' and (3) 'cell division and genetics' in order to specify the teaching moves about LA and HA students.

1. The question written for 'lifting force', referred to

'*K, L and M objects in different positions (floating, suspended, and sinking) in a liquid. He asked for the magnitudes of lifting forces to which these objects were subjected, sorted in descending order, (assuming the weights of all objects were equal)*'.

2. The question on 'states of substance and heat',

Mehmet asked *'50 ml and 100 ml of water were poured into two separate containers at equal temperatures, and he asked for the required heat quantities in order to increase the water temperature from*

20^0C to 50^0C to be compared.'

3. The question on 'cell division and genetics',

Mehmet asked the following question: "*What happens during the preparation and realization stages of mitosis cell division?*"

Mehmet was asked to express the moves he used while directing these questions to LA and HA students and for the process of solving them. At this stage, Mehmet was asked the following question:

"*What kind of alterations would you conduct if you use these questions to explain the scientific concepts and mechanisms in a class of either only LA students or HA students?*"

At the end of the data analysis, three major categories were identified:

- 'teaching moves about explanations',
- 'teaching moves about teaching strategies' and
- 'the dissimilarities causing the different teaching moves'.

The Teaching Moves About Explanations

Mehmet used three teaching moves in his explanations about scientific concepts and mechanisms: 1) changing the number of steps in the solution of the questions, 2) changing the number and the nature of the elaborations and 3) changing the nature of visual presentation of the mechanisms.

With respect to the first teaching move, Mehmet indicated he would solve the question related to the 'lifting force' in five steps for students in the LA classroom. In the HA classroom, he stated that he would combine the first three steps into one sentence in order to solve this question in a shorter time and with less detail.

Similarly, when he was asked what changes he would perform in seeking answers to the question about 'states of substance and heat', he said …

'*We solved the question in six steps here (for students in the LA classroom)'.*

However, I combined the first five steps into one in an HA classroom. Namely, "Heat is the total energy that the substance has. Temperature is the average motion energy per particle. The temperature of the heat-receiving substances increases and there is an inverse proportion between the mass and the temperature rise, that's all the correlation", this would be enough for high ability students to understand the first five steps".

Referring to the second teaching approach, in the case of the question about 'cell division and genetics', he argued that the students in the HA classroom would find the solution faster than those in the LA classroom and he therefore did not need to use elaborations in the HA classroom, whereas he used many for students in the LA classroom. He clarified this situation by saying

'*when I teach the main parts of a cell for students in the LA classroom, I certainly need to elaborate the topic by emphasizing the parts step by step, (by showing the parts of the cell on his drawing) such as this is the nucleus, that is the cytoplasm and as you remember we call this part the cell membrane'.*

On the other hand, it would be enough to express only the following for students in the HA classroom:

'My friends, as you remember, a cell has a spherical shape and it has the nucleus right in the middle.

I don't need to elaborate with a group of successful students, but we do need to elaborate and increase the number of examples with students in LA classes. '*I need to tell everything phase by phase'*.

In addition, he believed that he needed to change the nature of the elaborations. For example, he argued that the examples for students in the LA classroom particularly need to be selected from the daily life. He said ….

'First of all, the concept of heat needs to be explained to them clearly and in an easy way. Presenting the definition is not enough with this group of students; it would be adequate for a group of successful students, but you need to show that if you are with an LA class, this subject is generally taught in the winter months and the heaters are functioning.

I leave a cold metal object for 5-10 minutes on the heater and demonstrate the transfer of heat. I strive to explain the subjects with more examples from daily life in order to express that heat can be transferred between substances and the substances that lose heat becomes cold such as when you sit on benches in the winter months, when the cold bench can give you a cold because it removes heat from your body. Nevertheless, all these efforts fall short. Indeed, we need to repeat the subjects at the beginning of every lesson, and they require different examples'.

Regarding the third teaching move, for the solution of the three questions, Mehmet preferred step-by-step drawings in order to enable LA students to establish the relationships between the previous and later concepts (i.e., mechanisms), because he believed that the subject would be too abstract for LA students unless he used these drawings in turn. On the other hand, he presented the solution, solely based on definitions without benefitting from step-by-step drawings in the case of the HA students.

The Teaching Moves About Teaching Strategies

Mehmet used three teaching moves in his teaching strategies about scientific concepts and mechanisms: 1) changing the structure of scaffolding, 2) changing the nature of scientific practices, and 3) changing the nature of classroom technologies.

Regarding the first teaching move, Mehmet argued that for teaching the scientific concepts and mechanisms he needed to build a stronger scaffold, including pieces from very basic one through to a complex one for students in the LA classroom compared with the move in the HA classroom. About the question of 'cell division and genetics' he said when you say the word cell to a LA class, it would probably arouse a feeling of it being the first time they have been introduced to this word. For instance you might be faced with the question:

'Cell? What do you mean?

Therefore, here there is the need to introduce the cell, by talking about the organelles, explain their tasks, and even, if necessary, note the important ones in their notebooks as well as illustrate their shapes. Therefore, the students know what a cell is at least, and after that I can talk about cell division. With this type of class, I start from the very beginning and continue by adding steps one by one'.

Regarding the second teaching move, Mehmet stated that he needed to conduct experiments in the LA classroom, whereas the explanations without scientific practices were enough for students in the HA classroom. About the question related to 'lifting force', he said

'There would be alterations in the 1^{st}, 2^{nd} and 3^{rd} steps here. It would be enough to teach the subject in a good class by saying: the density of the substance is smaller than the density of the fluid, and it is definitely enough to say that the weight is equal to the lifting force. But for students in LA classes, it needs to be expanded more. I definitely need to show the floatation of the object with an experiment and produce daily-life observations'.

Regarding the third teaching move, in the case of 'cell division and genetics', Mehmet argued that he tried to make the subject more understandable by running a video display in order to illustrate the duplication process during the preparation phase of cell division. While having HA students merely watch the video is enough, for LA students, he explained his teaching move for this example as follows: '*first of all, I want them to watch the video and mention the processes shown in the video (by pausing it) and draw attention by saying "finally we have two cells now". And this is In addition to supporting my narration with images and pictures.*

The Dissimilarities Causing the Different Teaching Moves

Mehmet was asked during the interview, which was related to question generating, to think over the reasons for the teaching moves he said that he performed. It was revealed from the answers that there were many beliefs in Mehmet's mind about the dissimilarities between LA and HA students and these clear dissimilarities were possibly responsible for the moves. These were collected under two categories: 1) knowledge and 2) skills.

Knowledge. Mehmet was asked what knowledge components students needed to know in order to solve the three questions. Afterwards, he was asked to compare LA and HA students in relation to these knowledge aspects. He stated that LA students had difficulty in building up the concepts and in remembering the pre-conceptions about the subject, while HA students did not have the same problem. For example, in the case of 'cell division and genetics', he stated '*HA students knew the main parts of a cell but LA students didn't. Thus, I was forced to repeat the subject for the LA group'.* Similarly, in the case of 'lifting force', he said *' LA students remembered the 'name' of the topic because there is a subject named 'force and motion' every year…They also remembered what could happen when a force is applied, but they had no idea about calculation of resultant forces, or balanced and unbalanced forces*. Similarly, in the case of 'states of substance and heat', he indicated that HA students remembered the concepts of 'heat' and 'temperature', while LA students only knew the 'name' of the concepts without any idea about their content.

Skills. Mehmet listed a range of skills that were essential for solving the questions he produced. In the case of 'cell division and genetics', for example, he said that students must have *the ability to make correlations between the figures and notice the differences between the images in order to solve the questions*. He stressed that an effective visual intelligence was necessary for these processes and HA students were better at this intelligence than LA students. In the case of 'lifting force', he said that the students must have *ability to measure mass, perform volumetric metering and calculate density* in order to solve the question. While having the ability of mass measurement with an equal arm scale does not depend on whether the student is HA or LA student, but in fact, LA students had difficulty in the abilities of volumetric metering and density calculation. He referred to the ability of density calculation as *an easy division operation* for the HA students. Regarding the same ability, he emphasized that for LA students … *Here we are in trouble, especially if the result is decimal; In other words, if there is any digit after the comma then they might have difficulty in the division operation. We perform the division operation step by step for them and find the solution together.* In addition, in the case of 'states of substance and heat', he indicated these abilities as follows: *s/he must be capable of carrying out temperature measurement with a thermometer, designing an experiment by which heat transfer can be shown and computing.* Regarding the first, he gave the example of the situation for LA students: *they absolutely recognize a thermometer from previous years. However, somehow, the student can place the bulb the wrong way up. S/he might dip it into air instead of the liquid.* In contrast to the LA students, *even if the HA students haven't already used a thermometer, they are able to use it appropriately by examining the order of numbers on it*.

When LA and HA students were compared in terms of computing ability, he said that *LA students aren't able to compute. They have difficulty in performing either an addition or division operation.* In other words, Mehmet considered that LA students had limited measurement and computational skills. Also, he indicated that HA students had the ability to design an experiment related to the subject in their minds, whereas LA students could not imagine such designs and needed help from him.

Mehmet's Pedagogical Belief System

In order to reveal the pedagogical belief system of Mehmet, was interviewed with him on four topics: (a) beliefs about teaching motivation, (b) beliefs about science teaching motivation, (c) beliefs about science teaching practices and (d) beliefs about achievement differences in science classrooms.

Beliefs about Teaching Motivation

On teaching motivation, Mehmet argued that he chose the teaching profession because it was a more guaranteed profession than other alternatives. When he was asked why he is in the teaching profession, he replied that he had, in fact, wanted to be an engineer, but conditions forced him to take this path. However, he stated that after he became a teacher, his perception of the profession changed; he practices his profession with love, and so he continues to do it. When he was asked whether he believed that the teaching profession requires specialization, he considered that 'teaching at the level that LA students can learn' and 'strong communication with students' are important specializations that expert teachers had. Mehmet said: '*I think people who do not have communication skills, who cannot communicate with the student with a glance should definitely stay away from this profession. If s/he cannot teach at the level of the LA students can learn, behave warmly, and give confidence to them, then s/he should not become a teacher'.* He believed that the most important feature of a person who was going to practice the teaching profession was communication skills. He thought that there should be a trust-based relationship between teacher and student. Later in the interview, he answered the question of which profession he thought was like teaching, with the following*: 'it might be military officers*. When expressing the reason, he gave explanations based on didactic teaching by saying, *I received a good military training in a short time. And then we trained the soldiers with what we had learnt. (At the end,) There is a person, an individual in front of you, thus, I think that teachers might be similar to military officers'.*

Beliefs about Science Teaching Motivation

In the case of science teaching motivation, Mehmet was asked to share his thoughts about his teaching with such questions as: whether he believes that he can teach difficult subjects or not, how he improves his teaching in a difficult subject, and what the important factors are for the students to succeed or fail in science classes. Mehmet, who believed that he could teach difficult subjects, stated that he improved his teaching in a difficult subject by making connections with the real world and scaffolding. He said that: '*Force-Motion, for example, is a subject in which the LA students have difficulty. I start with an example that a student observes in daily life. For example, s/he knows that wood floats on water and stone sinks in water. It is a good beginning point for me. Starting from that point, I combine the examples and get the students to where I want them to be'.* Although he considered the students responsible for the cause of failing, he thought that a teacher and a student were responsible 50% - 50% for the success of a student in the science class. He stated that the content knowledge and pedagogical knowledge of the teacher did not have an effect, and what was important was establishing strong communication with the students. About whether the intelligence of a student had an impact on the success in science, Mehmet said:

'*A child listens to the lesson once and learns it, another student listens to the subject once and repeat it once, then s/he learns; your child learns it by repeating it three times. In conclusion, intelligence is important.*

Mehmet gave importance to intelligence in the science achievement of students and he believed that intelligent students could be successful just by listening to the lesson even if they did not study and did not do their homework. Mehmet indicated that some students needed support during teaching, by expressing his ideas as follows: '*some children listen and learn, some children listen, observe and then learn, some of them listen, observe, read and then learn, some of them need also to write, some of them need to repeat it two or three times too. Thus, I believe that every student can learn'.*

Beliefs about Science Teaching Practices

When the science teaching practices-oriented beliefs of Mehmet were examined, it was observed that he gave importance to making connection with the real world. When he was asked about how the best science teaching should be conducted, he said:

'*For example, when explaining the reproductive system of plants, it would be nice to teach it by taking the students to the schoolyard or going to a botanical garden. Or I would be willing to go to a forest, for instance, and explain there. Otherwise, when explaining weather events, I would like to teach that by climbing up a windy hill and lying down on the hill with the children'.*

Mehmet considered that the best science teaching could be provided by explaining the subjects that students can experience by themselves with examples from daily life. On the other hand, Mehmet supported the method of his students working as a group and talking about science topics with each other. Accordingly, he expressed that he strived to provide students who were at different achievement levels to work together. When he was asked which assessment and evaluation methods he used in science teaching, he said:

'*I use different types of questions such as multiple choice, true-false, filling in the blanks, concept maps, and puzzles. I diversify the questions. You hold an examination that consists of 5 questions and each of them will be 20 points. Generally, the LA child gets a low mark, but if you prepare the questions so that they include 10 fill-in-the-blanks, 10 True-False, 10 multiple choice, a concept map, and a puzzle, the content validity of the exam will increase'*. He stated that he used different types of questions in his examinations because he wanted not only the successful students but also the other students to get a high mark. In this context, Mehmet thought that he supported LA students.

Beliefs about Achievement Differences in Science Classrooms

In terms of his beliefs about achievement differences, the results showed that Mehmet had awareness about this topic. When he was asked about the reasons for achievement in the science classroom, he said: '*first, if the student comprehends the logic of the lesson, I mean, if s/he sees the place of it in life better, it allows him/her to be successful. Second is the communication; if his/her communication with the teacher is strong during the lesson, it is also effective'.*

He also stated that presenting different examples and alternatives related to the lesson and using visuals increased the success. In addition, he acted with the understanding that he could encourage LA students by using different methods in his teaching. He stated that he used extra criteria when evaluating the success of these students*: 'If s/he has good manners, be a gentle person, not interrupt my teaching in the class excessively … students should not be extremist, be slightly interested in the lesson, keep his/her book well, I even give extra points to that'.*

Relationships between Teaching Moves and Pedagogical Belief System

Looking at Figure 1, Mehmet's teaching moves seem to have a nested nature. He seems to contextualize his teaching strategies (that are more general thinking frameworks) on his explanations regarding the three questions. In the case of teaching strategies, for example, he argued that he would increase the length of his scaffolding when teaching the concepts and mechanisms to LA students by adding several basic pieces that he would not consider for HA students. Similarly, for the three questions he produced, he argued that he would increase the number of steps during the solution of them for the LA students, whereas he would combine several steps and use only the descriptions for the HA students. In one another teaching strategy, he considered that he would change the scientific practices if he particularly deal with the LA students in compare to HA students. For example, he stressed that he would design an experiment so that LA students could easily make a connection between science and daily life and easily understand the mechanisms. Similarly, for the solution of the three questions, he argued that he would benefit from a range of daily life examples and make some emphasizes in his explanations to the LA students. In one another teaching strategy, he said that he would change the nature of classroom technologies and argued that he would sometimes pause the videos and ask the questions in order to be sure that LA students make sense of the material. Similarly, within his explanations for the three questions, he argued that he would use many visual drawings and connection lines so that LA students could build cause-effect relationships in their minds.

On the other hand, Figure 1 displays that not only the pedagogical belief system of Mehmet that we uncovered using four components (teaching motivation, science teaching motivation, science teaching practices and achivement differences in science classrooms) was responsible for the teaching moves, but also some dissimilarity-oriented beliefs that we uncovered during the thinking-aloud interviews aiming to determine the teaching moves were effective. Therefore, it can be argue that the dynamic interrelationships among pedagogical belief system, dissimilarity-oriented beliefs and the teaching moves were responsible for

Mehmet's science teaching moves about achivement differences.

In one pathway covering these dynamic relationships, it can be argue that Mehmet's teaching epistemology that is strongly based on a behavioristic approach shape his dissimilarity oriented beliefs about knowledge and perhaps then his teaching moves regarding scafolding activities. In the teaching motivation interview, Mehmet, for example, resembled teaching profession to be a military officer and argued that these officers could teach the military activities from basic to complex to a range of people from very different educational background. Within this core epistemology, it seems that he believes that he needs to divide the topic into pieces, categorize these pieces from basic to complex and teach them by repeating and adding each via a conceptual scafolding approach. It seems that he consistently and heuristicaly consult this core epistemology when considering the achivement differences in science classrooms. For example, he argued that LA students had problems in remembering the pre-conceptions and building the conceptual frameworks, whereas HA students had a better picture in these thinking issues. Considering his core epistemology, this was an expecting result because scafolding is particularly based on remembering previous steps/layers and applying these pre-steps/pre-conceptions on the further steps/conceptions. Perhaps because of this belief about the scafolding problem within the LA students, he plays with the structure of the scafolding and change the number of solution steps in the three questions.

In one another pathway covering several other dynamic relationships, Mehmet's core belief about student learning within the depths of his pedagogical belief system seems to be responsible for several dissimilarity-oriented beliefs and perhaps then the teaching moves. Mehmet argued that he needs to diversify his science education by incorporating visuals and daily life examples when he considers that the students are struggling in understanding certain difficult topics. This argument may mean that he does not have any categorization in his mind as LA and HA students; rather, he may just believe that there are some difficult topics and he needs to teach them to all of the students by changing his teaching orientation. This core belief seems to have a relationship with another core belief which is his strong teaching efficacy to teach every topic to every type of student (i.e., 'every student can learn in my classroom' in his terms). Looking at his dissimilarity-oriented beliefs by taking into the connections between these two core pedagogical beliefs, Mehmet argued that several topics and questions required some skills that may not equally distributed among the students due to the genetical background (i.e., intelligence in his terms). However, if his emphasizes were investigated carefully, it can be argue that he attributed the difficulty to topics rather than the students. At this point, he believed that some science topics required some 'extra' skills such as experimental/design based thinking, visualization, contextualization of topic on the daily life, measurement and computation thinking that LA students had limited background and the practice. For helping and equalizing them with HA students, Mehmet changes the scientific practices and the nature of the classroom technologies because he believes that only the diversification of learning environment via the daily life examples, experiments, visual drawings and effective video usages can work antidotes against the skill inequalities.

DISCUSSION, CONCLUSION, RECOMMENDATIONS

In the present study, Mehmet's story was told. After long-term classroom observations with five other science teachers, it was felt that he might possess a rich belief set and teaching moves about achievement differences. The results showed that the expectation about Mehmet was correct.

Before sharing the discussion in terms of our comments and the comparisons between our findings and the existing literature, we need to emphasize that even though teachers' belief systems and teaching moves vary according to the teachers' identities, psychologies and sociologies, our aim in the present study was to uncover the dynamic relationships and possible relation pathways that other teachers might follow and ensuring the theoretical generalization (Yin, 2014). Even if the existing literature is almost silent on the teachers' perspectives regarding achievement differences except for several papers and policy documents, it was tried to map Mehmet's belief system using a relatively rich data set (classroom observations, thinking-aloud and semi-structured interviews) and the generalizations about teacher-belief literature.

First, consistent with existing literature (e.g., Barbier et al., 2022; Even & Kvatinsky, 2009; Jönsson, 2018), Mehmet conducts teaching moves according to achievement differences. However, distinct from previous limited number of studies focusing particularly on short-time observations, it is thought that Mehmet had complex and nested teaching moves about the achievement differences. He particularly changes his teaching strategies and contextualizes them on the daily teaching practices such as solving the questions. For example, he changes the structure of his scaffolding, scientific practices and classroom technologies according to the achievement differences. In the case of question solving, he increases the number of solution steps, conducts experiments and uses visual drawings and increases the time he devoted for watching the videos for LA students. Similarly, in Jönsson's (2018) research findings, while some teachers in the sample reduced the difficulties of assignments given to LA students, some teachers were against this practice. As Mehmet, these teachers considered that LA students should be given the same assignments with different scaffolding structures because all students should have the same opportunities and that LA students should be given more support. In addition, as a result of another study, it was stated that the use of scaffolding or not using scaffolding was not decisive for HA students to benefit from the curriculum, while the use of scaffolding was decisive for LA students. It was stated that interactive and adaptive scaffolds can support especially LA students in concept teaching (Reinhold et al., 2020). It is also stated that an appropriate scaffold is required to engage in metacognitive activities with LA students (Yang et al., 2016, 2020). Similarly, Mehmet argued that for teaching the scientific concepts and mechanisms he needed to build a stronger scaffold, including pieces from very basic one through to a complex one for LA students compared with to HA students.

Second, these teaching moves seem to stem from a two-layer belief system including dissimilarity-oriented beliefs and pedagogical belief system. Even if some science and mathematics teachers considered that higher order thinking activities were more appropriate for HA students (e.g., Torff, 2006) whereas the teaching based on transmission of knowledge (e.g., Zohar et al., 2001) or mechanic-answer-finding approach (e.g., Even and Kvatinsky, 2009) were more appropriate for LA students, we noticed that Mehmet did not have such strong beliefs categorizing the students or the classrooms and possibly exacerbating achievement gaps. Yes, he believes that there are several differences between LA and HA students in terms of concept building and thinking skills. However, like positive exceptional cases in the literature (Felch et al., 2010; Marzano et al., 2001), his two strong core beliefs (i.e., teaching efficacy and beliefs about student learning) in the depths of his pedagogical belief system such as 'every student can learn', 'every student can be successful in science courses if it is diversified by daily life examples, classroom technologies, etc.' or 'you should understand the situation of the student from only looking at his/her face' seem to provide him a positive belief background producing persistence and courage and preventing to build the prejudices. In addition, he seems to find some topics difficult to understand for 'all' of the students and they required further activities particularly for the students who are struggling due to limited conceptual background and skill sets. Similarly with the results of our study, the teachers also who participated in Shcmid's (2018) study believed that all student could and would learn and that all students could be successful when they provided appropriate instruction. In another study, some teachers believe that when given the right form of support and space, LA students are as capable as high achieving students in achieving success in school and in life (Fletcher, 2016; Hambacher & Thompson, 2015).

Last, Mehmet's teaching epistemology, one another core pedagogical belief, seems to produce the skeleton of the learning process first in his mind and then in the classroom. Even if his teaching epistemology seems to have behavioristic components such as producing knowledge pieces and teaching them from basic to complex via repetitions and scaffolding and such epistemology might make science even harder to understand for the LA students, it can be argue that this core belief may directly or indirectly diffuses into the other core beliefs, all of the dissimilarity-oriented beliefs and finally all of the teaching moves. Perhaps because of such epistemological filter developed through long-term preservice and in-service experiences (Pajares, 1992), he suggested the differences between LA and HA students in terms of knowledge and skills that are particularly important for behavioristic conceptual understanding. For example, he focused on the differences in terms of remembering pre-conceptions, visual intelligence, measurement and computation thinking and design-based experimental thinking and contextualization of the topic on the daily life evoking science teaching covering memorization and cookbook laboratory activities.

Conclusions and Implications

Considering that almost 20% of the students in OECD countries (OECD, 2018) performed under the basic level of scientific literacy and that there are many policy documents (such as NCLB, 2001 and PEP, 2018) aiming at closing the science achievement gap between the students, it was important to uncover Mehmet's, who produces explicit teaching moves taking the achievement differences into account, belief system and teaching moves in the present study. His data enabled us to see that the production of teaching moves according to the achievement differences is a complex phenomenon. Even if his teaching moves are questionable in terms of whether they are effective ones among many alternatives for closing the achievement gap and that we did not organize a longitudinal study covering the developments in his students, the findings showed that he contextualizes his teaching strategies on his daily science teaching practices and produces teaching moves according to the achievement differences using this nested set. In addition, three core pedagogical beliefs such as teaching epistemology, beliefs about student learning and teaching efficacy (Kilinc et al., 2017) seem to shape both dissimilarity-oriented beliefs and the teaching moves. At this point, first implication of the present study may be to uncover the belief system of preservice and in-service science teachers about the achievement differences. Within such reflection-oriented dialogic environments, the participants may make their core beliefs in the depths of their belief systems explicit, discuss the dissimilarities in their minds, listen different alternatives and see how their core beliefs shape dissimilarity-oriented beliefs. In follow-up activities, they may produce practical evidence in question solving (like the thinking-aloud interview) or in micro-teaching sessions (e.g., presuming that the teacher teaches same topic to one LA classroom and then one HA classroom). The science teacher educator in these dialogic and practical sessions may make the participants aware of their belief systems and the dynamic relationships between their beliefs and the teaching moves. If they can be supported by effective teaching moves tested within experimental studies, they may also evaluate the moves and suggest better ones. This point requires further research.

Even if the classroom observations about Mehmet seems to tell us the fact that he may produce some negative teaching moves possibly exacerbating the achievement gap, his belief set and the moves in question solving sessions displayed that some of his beliefs such as 'every student can be successful', 'if science teaching is diversified by daily life examples and classroom technologies, every student can understand science' and 'some topics are already difficult to understand to all of the students' might be suggested to incorporate into the science teacher educator's jargons.

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