Does Teacher Education Matter? Comparison of Education and Science Major Teachers' Assessment Literacy*

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Abstract: The purpose of this study was to investigate science teachers' assessment literacy having different majors (education versus science) and compare those teachers' assessment literacy. A multiple-case study, one of the qualitative research designs, was utilized to fulfill the aim. Four science teachers, two from each major, who were teaching at public schools during the 2017-2018 semesters, participated in the study. Pre-interviews, observations, post-interviews, and documents were used as data collection tools during the investigation. Content analysis was conducted using science teachers' assessment literacy model that exists in the literature. The findings of the study revealed that science teachers were similar and different from each other with respect to several dimensions of assessment literacy, which are views about learning, assessment purposes, assessment strategies, what to assess, and assessment interpretation. Recommendations for science education research and implications for science teacher education are provided.

Keywords: Science education, in-service science teachers, assessment literacy, case study

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Introduction

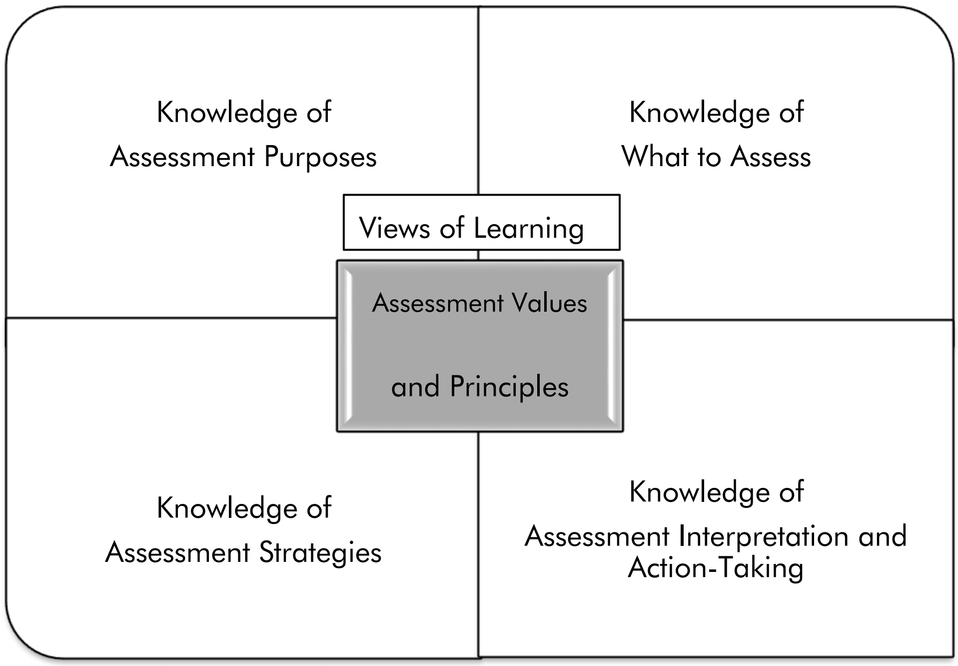
What are the activities that in-service teachers engage in throughout their instructional time? Activities conducted for assessment purposes take at least one-third of the instructional time (Stiggins, 1991). More importantly, research indicated that quality of assessment is linked to students' learning and enhancement of teaching (Box, 2008; Stiggins, 1999). For increasing assessment's influence on learning and teaching, "effectively designed learning environments must be assessment-centered" (Bransford, Brown & Cocking, 2000, p. 127). How can teachers design an assessment-centered learning environment? "…Teachers pay attention to the knowledge and beliefs that learners bring to a learning task, use this knowledge as a starting point for new instruction, and monitor students' changing conceptions as instruction proceeds" (Bransford et al., 2000, p. 11). That is, teachers should develop assessment literacy, which requires not only understanding theoretical and philosophical foundations of educational assessment but also effective utilization of assessment practices (Stiggins, 1991, 2002; Volante & Fazio, 2007). Knowledge and skills required to develop assessment literacy have been also defined as a part of teachers' pedagogical professional knowledge (Abell & Siegel, 2011; Magnusson, Krajcik & Borko, 1999).

Although assessment literacy is an important dimension of teachers' knowledge and teachers' assessment practices influenced by their literacy take considerable time of their instruction, there has been scarcity of studies investigating in-service science teachers' assessment literacy using qualitative measures. Most of the studies used an inventory to investigate teachers' assessment literacy and examined several factors affecting literacy such as teaching experience, attitude, efficacy, and conceptions of assessment (e.g., Levy-Vered & Nasser-Abu Alhija, 2015; Mertler, 2005; Quilter & Gallini, 2000; Volante & Fazio, 2007). Given the factors affecting assessment literacy, there has been a need for studies investigating whether education-related major area makes a difference in science teachers' assessment literacy. Studies using qualitative measures differed in their type. Some focused on the change in pre and in-service teachers' assessment literacy after participating in a professional development program or a course (DeLuca, Chavez, Bellara & Cao, 2013; Deneen & Brown, 2016; Koh, 2011) and relied on teachers' documents to reveal their assessment literacy without using observations. Other qualitative studies examined middle school science (Gottheiner & Siegel, 2012), chemistry (Izci & Siegel, 2019), pre-service physics (Ogan-Bekiroglu & Suzuk, 2014), and pre-service secondary (Siegel & Wissehr, 2011) teachers' assessment literacy during the planning and teaching a science topic. Even though there has been an increase in the number of research on assessment literacy relying on qualitative data, there has been scarcity of studies focusing on both knowledge and practice level of assessment literacy with its all dimensions (e.g., İzci, 2018). Therefore, the purpose of this study was to investigate science teachers' assessment literacy having different majors (education versus science) and compare those teachers' assessment literacy. Specifically, this study sought to answer the research question of "In what ways is assessment literacy different for science teachers with different majors (education versus science)?"

This study utilized Science Teacher Assessment Literacy (STAL) model (Abell & Siegel, 2011). There have been several reasons for this. First, the model is specific to science teachers. Second, the model was proposed based on the empirical and theoretical literature on teachers' assessment knowledge and practices. Lastly, literature provided empirical evidence for the applicability of the model for investigating both pre and in-service science teachers' assessment literacy (Gottheiner & Siegel, 2012; İzci & Siegel, 2019; Siegel & Wissehr, 2011). STAL model defines assessment literacy as assessment knowledge and skills, which teachers require while designing an assessment-centered learning environment (Abell & Siegel, 2011). In an assessment-centered learning environment, teachers investigate students' knowledge and skills, interpret the assessment results, and utilize the results to increase students' learning and teaching practice (Abell & Siegel, 2011; Xu & Brown, 2016). Figure 1 shows STAL model guiding this study.

Figure 1.

A Model for Science Teacher Assessment Literacy (Abell & Siegel, 2011, p. 212).



STAL model consists of five components. Assessment values and views of learning as a whole is central to the model and this core component influences other four components, which are knowledge of assessment purposes, what to assess, assessment strategies, and assessment interpretation and action-taking.

Teachers' view of learning has a shaping effect on how teachers conceptualize and utilize assessment throughout instruction (Abell & Siegel, 2011; Xu & Brown, 2016). A teacher whose view of learning is constructivist use assessment for revealing, monitoring, and developing students' learning throughout his/her teaching while a teacher with a traditional view of learning prefers to utilize assessment to determine the degree to which students mastered what they are expected to learn at the end of his/her teaching. Assessment values and principles are based on both teachers' views of learning (Shepard, 2000) and assessment experiences in science teaching (Abell & Siegel, 2011). These values and principles are the fundamental ideas and beliefs that lead teachers during assessment decisions they make in their science classroom (Abell & Siegel, 2011).

STAL model (Abell & Siegel, 2011; Xu & Brown, 2016) advocates that an assessment literate teacher should possess a complete understanding about assessment purposes, what to assess, assessment strategies, interpretation, and utilization of assessment results. Knowledge of assessment purposes refers to teachers' reasons for assessing students. Why teachers assess students can be categorized as diagnostic, formative, summative, and metacognitive (Abell & Siegel, 2011). Diagnostic assessment is the assessment occurring at the beginning of teaching for both eliciting students' prior conceptions, knowledge, and beliefs about the topic being taught and using those to regulate teaching (Abell & Siegel, 2011). Formative assessment is the assessment occurring throughout the instruction for giving feedback to both students and teachers about learning and teaching for enhancement of them (Abell & Siegel, 2011). Summative assessment is the assessment occurring at the end of a class, unit or semester to document students' learning and mostly giving course grades. It also provides feedback to teachers about their teaching (Abell & Siegel, 2011). Lastly, metacognitive assessment is the assessment conducted to increase students' awareness about their learning as well as monitor it. Knowledge of what to assess refers to dimensions of learning that teachers believed to be important to assess and based on teachers' assessment values and views of learning (Abell & Siegel, 2011). Students' attainment of curricular objectives, scientific and engineering practices, and nature of science can be included in the assessment tasks that teachers used. Knowledge of assessment strategies refers to the various ways teachers used to assess. Assessment strategies can be categorized as formal and informal (Abell & Siegel, 2011). Formal strategies include exams, lab reports, quizzes, homework, tests, advance organizers, etc. Formal strategies are the ones that teachers use to evaluate students throughout instruction. Informal strategies include classroom discussions and observation of students, and teachers' primary aim is not to give grades to students. Knowledge of assessment interpretation and action taking refers to what teachers do with the assessment data (Abell & Siegel, 2011). Eliciting students' existing knowledge, providing feedback to students, monitoring students' learning, controlling and regulating teaching, giving grades, etc. are examples of how a teacher can interpret and act upon assessment results.

Literature review on science teachers' assessment literacy revealed that studies could be grouped as (1) studies using quantitative data sources, (2) qualitative studies, and (3) studies investigating the impact of an intervention on assessment literacy.

Studies in the first category used quantitative data sources to determine either pre-service (Gul, 2011; Ogan-Bekiroglu & Suzuk, 2014) or in-service teachers' (Davidheiser, 2013) assessment literacy in different areas of science using an already existing instrument (Gul, 2011) or an instrument developed by the researcher (Ogan-Bekiroglu & Suzuk, 2014). Participants of the studies conducted with pre-service teachers were science (Gul, 2011) and physics (Ogan-Bekiroglu & Suzuk, 2014). Results of these studies indicated that pre-service science teachers' assessment literacy level was low, and they have difficulties especially in communicating assessment results. Moreover, they were not highly capable of selecting and developing appropriate assessment methods and interpreting and using assessment results. A study conducted with pre-service physics teachers categorized participants in terms of the degree to which their assessment literacy is constructivist (Ogan-Bekiroglu & Suzuk, 2014). Pre-service physics teachers' assessment literacy levels were identified as close to constructivist in terms of types of assessments, evaluation criteria, and cognitive levels of assessments. However, in-service science teachers' assessment literacy levels were found as high (Davidheiser, 2013) with regard to selecting and developing appropriate assessment methods, and interpreting, using and communicating assessment results based on data obtained from an existing instrument in literature. While results obtained from quantitative studies provide insight about teachers' assessment literacy level, it was advocated that reliability and usability supporting measures of assessment literacy is weak (DeLuca, LaPointe-McEwan & Luhanga, 2016) since the construct is multidimensional in nature. This study comes into prominence since it uses qualitative data to reveal teachers' assessment literacy both in the theoretical and practical realm.

Qualitative studies on assessment literacy mostly focused on either pre-service (i.e., Ogan-Bekiroglu & Suzuk, 2014; Siegel & Wissehr, 2011) or in-service (i.e., Gottheiner & Siegel, 2012; İzci & Siegel, 2019) science teachers' literacy. One study in this category conducted a descriptive content analysis on empirical studies investigating secondary science teachers' assessment knowledge and practice using the assessment literacy framework (İzci, 2018). Most of the studies utilized an existing theoretical framework (e.g., STAL) while two studies developed their own framework (Ogan-Bekiroglu & Suzuk, 2014; Siegel & Wissehr, 2011). One study defined assessment literacy as types of assessments, evaluation criteria, and cognitive levels of assessment, considering dimensions about assessment as defined by others (Ogan-Bekiroglu & Suzuk, 2014), and another study advocated that assessment literacy included assessment principles, purposes, and tools of assessment (Siegel & Wissehr, 2011). Results of the studies conducted with pre-service teachers revealed that although pre-service teachers' assessment literacy was close to constructivist view, in theory, their assessment practices were more traditional. Studies conducted with in-service teachers yielded similar findings (Gottheiner & Siegel, 2012; İzci & Siegel, 2019). Content analysis of studies regarding assessment knowledge and practice (İzci, 2018) indicated that there have not been longitudinal studies on assessment literacy. Moreover, it was revealed that most of the studies investigated assessment knowledge and perception, and focused on espoused assessment instead of enacted one. Therefore, this study is valuable since assessment literacy with its all dimensions was investigated both in theoretical and practical realm through the use of observational and interview data collected during the teaching of matter, and its change unit spanned four weeks.

Studies in the third category investigated the effect of either a course on pre-service science teachers' assessment literacy (Akdağ-Gürsoy, 2015; Buldur, 2009) or a professional development program on in-service science teachers' assessment literacy (Koh, 2011). One of the courses designed for pre-service teachers was a content and implementation-based assessment course (Akdağ-Gürsoy, 2015) and the other was a theoretical and practical course on alternative assessment (Buldur, 2009). Both courses were found to be effective in increasing pre-service science teachers' assessment literacy (Akdağ-Gürsoy, 2015; Buldur, 2009), attitudes (Akdağ-Gürsoy, 2015), and self-efficacy (Buldur, 2009). Professional development program designed for in-service science teachers included authentic task design and rubric development for assessment (Koh, 2011). Results of this study revealed that professional development program increased the intellectual quality of both teachers' and students' assessment tasks.

Methodology

Research Design

This study is qualitative (Marshall & Rossman, 2011) since teachers' assessment literacy is implicit (Loughran, Mulhall & Berry, 2004) and complex in nature (Abell & Siegel, 2011). Qualitative research has the potential to make science teachers' assessment literacy explicit and understandable. Among qualitative research designs, case study guided the study. Case study is the study of an issue investigated through one or more cases within a bounded system (i.e., setting, a context) (Creswell, 2007) and provides an in-depth portrayal and analysis of a particular practice, process, or event (Yin, 2009). Science teachers' assessment literacy (i.e., practice and knowledge) within the context of "Matter and its Change" unit (i.e., bounded system) was investigated in this study. Case study also purposes to expand theories (Yin, 2009) and this case study aimed to expand STAL proposed by Abell and Siegel (2011). Considering the size of the bounded case, this study is an example of multiple-case study. Multiple-case study is conducted for either predicting similar results (a literal replication) or predicting contrasting results (a theoretical replication) through the use of different cases, which are different from each other in some respect (e.g., experienced teachers and beginning teachers) (Yin, 2009). In this study, science teachers were grouped into two, of which each was unique in terms of their major degrees (i.e., education and science) and hence these groups constituted different cases. This study aimed to predict to what degree major is central in science teachers' assessment literacy through the use of those contrasting cases. The unit of analysis of this multiple case study was the assessment literacies of science teachers with different majors. Analysis of participants' assessment literacies in both knowledge and practice level was considered in this study. Therefore, assessment literacy in knowledge level and assessment literacy in practice level constituted an embedded unit of analysis of this study.

Participants

Four in-service science teachers, who were volunteers and information-rich cases, participated in the study (Table 1). Two of the participants graduated from science teacher education (Oguz* and Ahu) program at a faculty of education and the other two (Sarp and Miray) graduated from the faculty of arts and science with a focus on chemistry.

Table 1.

Demographic Information About Participants

Participant	Degree	Teaching Experience in Years	Grades Taught
Oguz	Faculty of Education Science Teacher Education	9 years	5th, 6th, 7th and 8th
Sarp	Faculty of Arts and Science Chemistry	23 years	Two years in elementary 5th, 6th, 7th and 8th
Ahu	Faculty of Education Science Teacher Education	25 years	5th, 6th, 7th and 8th
Miray	Faculty of Arts and Science Chemistry	25 years	5th, 6th, 7th and 8th

* All names of the participants are pseudonyms

Context of the Study

The study was conducted in two public middle schools in Safranbolu county of Karabük, Turkey. Achievement rankings of the schools were better than other schools in the county. The socioeconomic status of students in the schools was high and the schools had necessary facilities for teachers and students (e.g., laboratory with its materials and equipment). In each of the schools, there was one education major and one science major teacher. Oguz and Sarp were studying at one school while Ahu and Miray were in the other. The contexts where observations were conducted will be explained below.

Oguz teaches science in class and laboratory. There were 29 students in his science class and two students sit in each row. There were nine desks in the laboratory and students work in predetermined groups at those desks. Although the laboratory has basic materials, there has not been sufficient equipment for each student. Therefore, Oguz has to prefer demonstrations instead of making students conduct experiments. Both the class and laboratory have smartboards.

Sarp teaches science in class and laboratory. There were 29 students in his science class and two students sit in each row. There were seven desks in the laboratory and students work in predetermined groups at those desks. Although the laboratory has basic materials, there has not been sufficient equipment for each student. However, Sarp enables his students to conduct experiments. Both class and laboratory have smartboards.

Ahu teaches science in class and laboratory. There were 32 students in her science class and two students sit in some rows while one sits in others. There were three desks in the laboratory and 10 students can work at each of those desks. The laboratory has a majority of materials required for experiments and observations. However, Ahu prefers using demonstrations since the class is crowded. Both class and laboratory have smartboards.

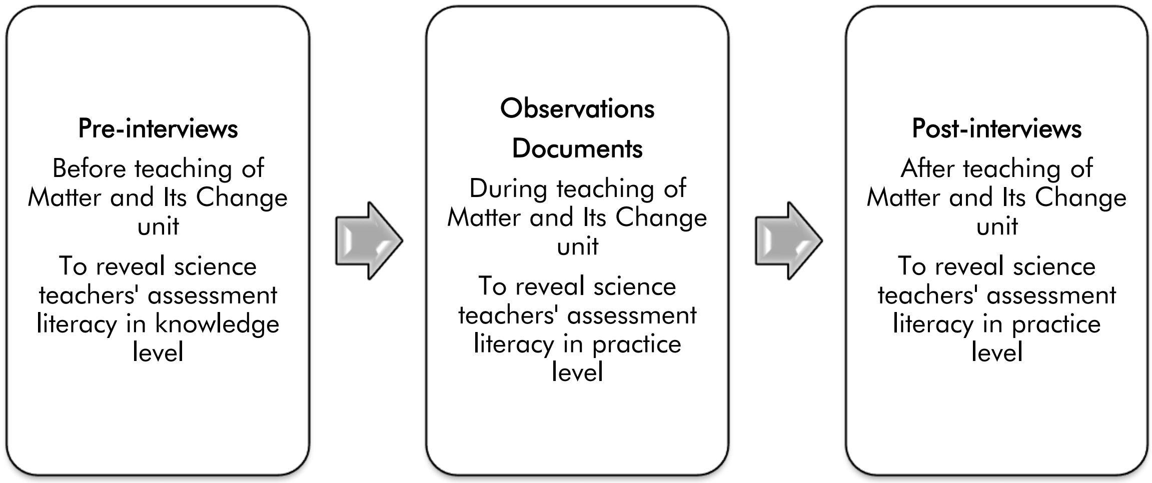
Miray teaches science in class and laboratory. There were 33 students in her science class and two students sit in each row. There were three desks in the laboratory and 11 students can work at each of those desks. Although the laboratory has basic materials, there has not been sufficient equipment for each student. Because of the lack of materials and crowded class, Miray prefers demonstrations. Both class and laboratory have smartboards.

Data Collection Sources

Qualitative data sources were used in this study to reveal and compare science teachers' assessment literacy having different majors, as summarized in Figure 2.

Figure 2.

Flowchart for Data Collection



Semi-structured pre-interviews were conducted with four participants before they teach the unit of Matter and its Change. Semi-structured interview questions were prepared based on STAL model (Abell & Siegel, 2011) guiding the study and empirical studies on assessment literacy (İzci, 2018). Pre-interview questions focused on teachers' demographic information, assessment values and views of learning as a whole, knowledge of assessment purposes, knowledge of what to assess, knowledge of assessment strategies, and knowledge of assessment interpretation and action-taking (see Appendix A for selected questions).

Observations were used to collect data about participants' assessment literacy in practice level throughout their teachings of Matter and its Change unit. There were several reasons for selecting "Matter and its Change" unit. First, one of the researchers was an expert on chemistry education, which enabled her to capture science teachers' assessment literacy in this unit. Second, this unit was suitable for using various assessment methods that provided opportunity for science teachers to enact their assessment literacy and hence to collect rich information. Lastly, conducting the study during the teaching of this unit was convenient for researchers. The second researcher as a non-participant observer used an observation protocol (see Appendix B) and took field notes considering STAL model (Abell & Siegel, 2011) guiding the study and teachers' responses to pre-interviews. Moreover, documents that teachers utilized for assessment purposes during teaching were collected to gain in-depth information about teachers' assessment literacy in practice level. Examinations, textbooks that teachers utilize for assessment activities, educational websites used by teachers for teaching and assessment purposes, homework, and science laboratory reports prepared for students and assessed by teachers were the main documents used in this study.

Post-interviews were conducted to collect additional data about participants' assessment literacy in practice level after teaching of Matter and its Change unit. Questions in post-interviews were peculiar to each participant since their assessment practices were different from each other. Observations and field notes were considered during the preparation of post-interview questions (see Appendix A).

Data Analysis

Data obtained from pre-interviews, observations, post-interviews, and documents were analyzed using both deductive and inductive analysis (Patton, 2002). Deductive analysis was the main analysis method while inductive analysis was utilized as required during the analysis of science teachers' assessment literacy. Comparing assessment literacy of science teachers with different majors was also inductive and required using the constant comparative method (Glaser & Strauss, 1967). Analysis of participants' STAL in both knowledge and practice level was conducted primarily deductive. STAL model (Abell & Siegel, 2011) and empirical study on assessment literacy (İzci, 2018) provided codes for deductive analysis of STAL components, namely, assessment values and views of learning as a whole, knowledge of assessment purposes, knowledge of what to assess, knowledge of assessment strategies, and knowledge of assessment interpretation and action-taking. Moreover, researcher-created codes were used for the inductive analysis of data when existing codes were not appropriate to code. Pre-interviews were the main data sources while analyzing STAL in knowledge level whereas observations, post-interviews, and documents provided data during analysis of STAL in practice level (see Table 2 for the coding scheme and selected data analysis examples. Codes written in italics indicate researcher created codes). Comparing STAL of science teachers with different majors was inductive in nature, which is defined as "discovering patterns, themes, and categories in one's data" (Patton, 2002, p. 453). The researchers used the constant comparative method during inductive analysis (Glaser & Strauss, 1967). The constant comparative method involves comparing two segments of data to determine similarities and differences (Merriam, 2002). Coded data regarding science teachers' STAL in practice level was compared and contrasted to find similarities and differences between STAL of participants with different majors. The same procedure was applied for comparing and contrasting coded data for science teachers' STAL in knowledge level.

Table 2.

Coding Scheme Including Codes and Examples of Coding

Component	Sub-component	Coding example
Views of learning	• Goals for teaching learners	• Teaching what is planned to teach "Purpose of education is to teach a planned idea, planned part to students." (Oguz, pre-interview)
	• Teacher role	• Encourage students for their learning • Ensure active participation of students in the learning process • Guide students to support their learning "My role during teaching is to ensure students' active participation in the class and be a guide for them. In the past, it was not like that; we were active during teaching. Within the context of a changed system, I believe that encouraging students' active participation will give positive results in terms of learning." (Oguz, pre-interview)
	• Student role	• Be prepared for teaching • Active participation • Be responsible and effective individuals "Students' roles during teaching are being prepared for the class by bringing textbooks and notebooks, answering questions in class, and being effective individuals who are aware of their responsibilities." (Sarp, pre-interview)
	• Teaching sequence	• Teaching topic • Using question-answer method • If the topic is related to topics learned in previous grades, using the question-answer method to elicit students' prior knowledge • Implementing assessment tasks in textbooks (Miray, observation)
	• *Teaching sequence in laboratory*	• Asking questions to elicit students' prior knowledge about the topic • Giving feedback based on students' responses • Performing experiments as demonstrations • Making students conduct experiments if necessary materials exist • Making students watch a video of experiments if it is not applicable to conduct in the laboratory • Asking questions about the experiment • Giving feedback based on students' responses (Oguz, observation)
Perception of assessment	• Assessment for teachers	• Eliciting students' prior knowledge • Determining whether learning is achieved or not • Grading students "Assessment is to seek answers to the questions of What do students remember from previous grades related to the topic? Could students learn what I teach? Does learning occur? The first thing that comes to my mind about assessment is to grade students." (Miray, pre-interview)
	• Assessment for students	• Ensuring students' learning through the use of assessment • Determining students' level of learning for the topic • Providing the opportunity to students to check their learning difficulties and misconceptions if exists "Assessment should be designed considering students' level if the assessment is expected to be appropriate to its aim. Because students' levels are different from each other and you cannot assess students if you stick with one method. When I determine students' difficulties or misconceptions, I am trying to learn the degree to which learning occurred". (Miray, pre-interview)
Purpose of assessment	• Diagnostic	• Eliciting students' prior knowledge "My purpose of assessment is to elicit students' prior knowledge." (Miray, pre-interview)
	• Formative	• Eliciting students' learning difficulties and misconceptions • Giving feedback to students by encouraging them to learn • Creating a context for students' learning • Helping students to develop their learning • Helping teachers to monitor students' learning level • Helping teachers to check their teaching "My formative assessment purposes are to determine students' learning difficulties and misconceptions, to develop students' learning and encourage for learning, to create a context where students organize their learning, to monitor students' level of learning, and to check my teaching." (Oguz, pre-interview)
	• Summative	• Determining students' achievement level of objectives • Grading students "My summative assessment purposes are to determine students' achievement level of

		objectives and grade students." (Ahu, pre-interview)
What to assess	• Factual knowledge	• Which one of the followings is not a factor that affects the rate of dissolution? A) Temperature B) Stirring C) Particle size of solute D) Type of solvent (Sarp, observation, a question posed during teaching)
	• Conceptual knowledge	• What are the properties of elements and compounds? (Miray, observation, a question posed during teaching)
	• Procedural knowledge	• Determine the charge of atoms of which proton and electron numbers are given. (Oguz, observation, a question posed during teaching)
	• *Nature of science*	• Construct the models of atom throughout history and compare them. (Ahu, documents, a homework given to students)
Assessment strategies	• Formal	• Test Homogeneous mixtures are called as………………… Homogeneous liquid-liquid mixtures are separated with……………………… method (Sarp, documents, question examples in test)
	• Informal	• Teacher observation "Think that I ask a question to a successful student and the answer was wrong. After a while, I will ask a question at the same difficulty level to that student. The student's answer might be right or wrong. If the answer was wrong, I did not evaluate the student as s/he did not know the right answer. The student might be sick or forget the answer. I consider these kinds of situations. I use observations throughout my all teaching practices." (Ahu, post-interview)
Assessment interpretation and action-taking	• Eliciting students' prior knowledge	• What is a cell? • What is an atom? "You learned about the cell in previous grades. What do you know about cell? What was cell? Do you remember what atom was?" (Miray, observation, questions posed to elicit students' prior knowledge)
	• Determining students' learning difficulties	• Elements are represented by………. • (…) Heterogeneous mixtures are called as solutions. • (…) Salty water, lemonade, and vinegar are examples of homogeneous mixtures. • Oxygen ion has 8 protons and 10 electrons. Is oxygen ion anion or cation? "Let's review what we learned in the previous class. Let's answer the questions so that we can see what is missing. (Ahu, observation, question posed at the beginning of instruction to determine students' learning difficulties)
	• Determining students' misconceptions	• What are the characteristics of elements and compounds? • What is anion? What is a cation? • Give examples for homogeneous and heterogeneous mixtures. "Are there anyone who confuses homogeneous and heterogeneous mixtures? What were homogeneous and heterogeneous mixtures? Could you give examples? For instance, Is salty water homogeneous or heterogeneous?" (Miray, observation, questions posed for determining students' misconceptions)
	• Determining students' levels of learning	• What is an atom? • Who proposed the idea of the atom first? • What are the atom models from the beginning to our day? (Ahu, observation, question ordered from easy to hard and posed to determine students' levels of learning)
	• Teachers' checking their teaching	• Every country uses………..symbol for the same element. • What are the atom models from the beginning to our day? • Which one of the following is a compound? a. Sodium b. Fluorine c. Ammonia d. Copper • (…) Heterogeneous mixtures are called as solutions. (Ahu, observation, questions posed for checking teacher's teaching)
	• *Creating a context for ensuring students' learning*	• (…) Mixtures are pure substances. Oxygen molecule consists of………..kind of atoms and glucose molecule consists of………..kind of atoms. (Oguz, observation, question posed for creating a context for ensuring students' learning)
	• *Encouraging students' peer and learning*	• Oguz: Ayşe, can we call everything as matter around us? • Student (Ayşe) Yes, everything around us is a matter. • Oguz: Are you sure? Is everything matter? Is there anyone who has thoughts about that? Isa, is everything around us matter? • Student (Ilgaz): No. Everything that has mass and occupies space is matter. There are things like light, sound, and temperature, which are not matter. • Oguz: Yes, little Einstein. Ayşe, as your friend says there are things, which are not classified as matter. (Oguz, observation) "Students could see what is wrong. Priority is whether they notice if there is something wrong and if they are aware of it. Sometimes, students can learn from their peers instead of me. Peers could give a more familiar example." (Oguz, post-interview)

• *Ensuring students' attainment of objectives*	• Which one of the following is not a sub-atomic particle? a. Proton b. Neutron c. Electron d. Ion (Miray, document, question posed in the exam) "One of my purposes for assessment to ensure students' attainment of objectives. Therefore, I pay attention to the objectives when preparing exam questions." (Miray, post-interview)
• Giving feedback to students	• Sarp: What is an atom? • Student (Rüzgar): Smallest particle of matter. • Sarp: Yes, well done. Rüzgar. • Sarp: Who is the first scientist who called negative sub-atomic particles as electrons? • Student (Meltem): Rutherford • Sarp: Feyza, Is Rutherford the scientist who called negative sub-atomic particles as electrons? • Student (Feyza): No, Thomson is the scientist who called negative sub-atomic particles as electrons. • Sarp: No, Thomson is the scientist who called negative sub-atomic particles as electrons. (Sarp, observation, feedbacks (as yes, no, well done) given to students)
• *Grading students for their learning*	• Exam List factors affecting the rate of dissolution. (5pts) • Classroom evaluation • Ahu: Kübra, please come to the board. How do we symbolize nitrogen? • Student (Kübra): We use the letter "N" teacher. • Ahu: Well, what is nitrogen, and what are its properties? • Student (Kübra): Nitrogen is an element and exists in living organisms. • Ahu: Well done, Kübra. I give you "+" (Ahu, observations, questions, and grades given as "+")
• *Grading*	• Homework in textbook Which one of the following is not a symbol of an element? A. OH^- B. Cl C. S D. Au • Exam question Information about X, Y, and Z is given as follows. X: Symbols are used to represent X. Y: Formulas are used to represent Y. Z: Neither symbols nor formulas are used to represent Z. Which of the following is true for X, Y, and Z? X / Y / Z A) Element / Mixture / Compound B) Mixture / Element / Compound C) Element / Compound / Mixture D) Compound / Mixture / Element (Oguz, documents, questions used in exams for grading)

Credibility and Ethical Issues of the Study

The researchers utilized triangulation, prolonged engagement, and member checks to ensure credibility. Triangulation of sources and analyst/investigator triangulation were used to increase credibility (Patton, 2002). Using data from multiple sources (i.e., pre-interviews, observations, documents, and post-interviews) for data collection and analysis helped us to ensure triangulation of source. Analyst/investigator triangulation was achieved through independent analysis of data by two analysts. The second researcher spent six weeks in the research setting and with the participants, which ensures prolonged engagement. Her entry began with introducing the study with permissions from the Institutional Review Board, Ministry of National Education, school administrators, and participants. Then, the researcher conducted pre-interviews, observations, and post-interviews by being present in the research site all the time. After analysis of data, findings about teachers' assessment literacy in both knowledge and practice level were shared with the participants. Participants agreed with the findings and hence we assured member checks.

All research activities were conducted in alignment with the permission of the Zonguldak Bülent Ecevit University Institutional Review Board (Date: 30.11.2017, Protocol number: 269) and Ministry of National Education. The voluntary participation of all teachers was ensured through a written consent form. Participants were told to withdraw from the study whenever they want and that no one except researchers had access to data. Moreover, participants were informed that pseudonyms would be used when reporting the study. Through this, issues regarding ethics in research, such as protection of the participants from harm, and confidentiality were assured (Fraenkel & Wallen, 2006).

Findings

Comparison of Teachers' View of Learning and Perception of Assessment

Teachers' views of learning were compared considering their views about goals for teaching, teacher role, student role, teaching sequence, and laboratory teaching sequence (Table 3). With respect to goals for teaching, education major teachers had topic and concept teaching-related goals whereas science major teachers' goals focused on helping students to become individuals who have knowledge and skills of both society and era. When teachers' views about their roles during teaching were compared, it was revealed that education major teachers adopted the guide role who encourage students for both their learning and active participation. However, science major teachers had affective variable-focused goals such as increasing students' interest in science lessons and being role models for students. Considering student roles, all participating teachers believed that students should be active and responsible for their learning. In terms of teaching sequence emphasizing the importance of the topic, informing students about the topic's relation to previous topics, and using the questioning method were the common activities conducted by all participants. However, education major teachers elicited students' prior knowledge at the beginning of instruction through questioning right after informing students about the importance and relation of the topic whereas only one science major teacher (Miray) did after teaching the topic. The teaching of the topic occurred at the beginning of instruction in science major teachers' instructions while education major teachers taught the topic after emphasizing the topic's importance and eliciting students' prior knowledge. Using an online educational platform (e.g., MorpaKampüs and Eba) purposively for both teaching and assessment occurred only in education major participants' classes. With respect to teaching sequence in the laboratory, education major teacher Sarp was the one who designed instruction to enhance students' learning in the laboratory.

Teachers' perceptions of assessment were compared considering assessment for teachers and assessment for students (Table 4). All participating teachers perceived assessment as a vehicle to elicit students' prior knowledge. However, only education major teachers viewed assessment as a way to elicit students' difficulties and misconceptions. Interestingly, determining students' level of learning existed in one education major (Oguz) and one science major (Sarp) teacher's perception of assessment for teachers. Using assessment for grading was more prevalent among science major teachers. With respect to assessment for learner, all teachers believed in using a variety of assessment methods. Using assessment as a way to encourage students for learning was emphasized by all education major teachers and one science major teacher (Miray). One education major (Ahu) and one science major (Sarp) teacher considered assessment as a tool to help students achieve objectives. Similarly, the idea of using assessment to provide feedback to students about their learning was observed in education major (Oguz) and one science major (Miray) teacher.

Table 3.

Comparison of Participant Teachers' Views of Learning

Views of learning	Oguz (Education)	Ahu (Education)	Sarp (Science)	Miray (Science)
Goals for teaching	• Teaching what is planned to teach	• Being a model for students • Educating students equipped with knowledge • Helping students to gain good status in society	• Helping students to become an individual of the society • Equipping students with the knowledge and skills of the era • Helping students to become an individual who values his/her nation and flag and protects his/her values	• Helping students to gain good status in society • Helping students to protect cultural values • Helping students to become aware of developments in the world
Teacher role	• Encourage students for their learning • Ensuring students' active participation in their learning • Guiding students to support their learning	• Ensuring students' active participation • Encouraging students to learn • Guiding students	• Making students have positive attitudes towards science lesson • Taking students' attention to science lesson through relating science to daily life and having students conduct experiments that are appropriate to their interest and expectations	• Being a role model who is caring for to environment and communicating with people • Helping students to be prepared for the statewide examinations
Student role	• Active participation • Being responsible and effective individuals	• Active participation • Being prepared for the class • Being responsible and effective individuals	• Being prepared for the class • Active participation • Being responsible and effective individuals	• Active participation • Being responsible and effective individuals • Being interested in the class
Teaching sequence	• Informing students about the importance of the topic and objectives to be achieved • Implementing questioning method to elicit students' prior knowledge if the topic is	• Informing students about the importance of the topic and relation of the topic to previous and subsequent topics lementing questioning method to elicit students' prior knowledge	• Informing students about the importance of the topic and objectives to be achieved • Teaching topic through lecturing	• Teaching topic through lecturing • Using questioning method if the topic is related to topic learned in previous

	related to the topic learned in previous grades • Giving feedback to students who have difficulties and misconceptions • Teaching topic • Using questioning to determine whether learning occurred • Having students watch an on-line and topic related video in an educational portal (Morpa Kampüs and Eba) • Using online assessment activities in an educational portal and giving feedback to students (Morpa Kampüs and Eba)	• Giving feedback to students who have difficulties and misconceptions • Using teaching and assessment activities in the textbook • Having students watch an on-line and topic related video in an educational portal (MorpaKampüs) • Using online assessment activities in an educational portal (MorpaKampüs)	• Note-taking to whiteboard • Using questioning to determine whether learning occurred • Having students watch an on-line and topic related video in an educational portal (MorpaKampüs) and asking questions related to the topic • Giving feedback to students	grades • Using assessment activities in the textbook
Teaching sequence in laboratory	• Asking questions about the topic to elicit students' prior knowledge • Giving feedback based on students' responses • Conducting experiments as demonstrations • Making students conduct the experiments if necessary materials exist • Making students watch a video of the experiment (from Morpa Kampüs) if it is not applicable • Asking questions about the experiment • Giving feedback based on students' responses	• Informing students about laboratory rules • Performing experiment as a demonstration • Asking questions	• Making students conduct the experiment • Asking questions about the experiment	• Performing experiment as a demonstration • Asking questions about the experiment

Table 4.

Comparision of Participant Teachers' Perceptions of Assessment

Perception of assessment	Oguz (Education)	Ahu (Education)	Sarp (Science)	Miray (Science)
Assessment for teachers	• Eliciting students' prior knowledge • Determining students' difficulties and misconceptions • Determining students' level of learning	• Eliciting students' prior knowledge • Determining students' difficulties and misconceptions • Grading	• Eliciting students' prior knowledge • Giving feedback to students • Grading	• Eliciting students' prior knowledge • Determining students' level of learning • Grading
Assessment for students	• Using a variety of methods to provide equitable opportunities to students • Encouraging students for learning • Providing feedback to students to eliminate their difficulties and misconceptions	• Using a variety of methods to ensure students' learning • Helping students to achieve objectives • Encouraging students for learning	• Using a variety of methods to ensure students' learning • Helping students to achieve objectives • Encouraging students for learning	• Using a variety of methods to ensure students' learning • Determining students' level of learning • Providing students the opportunity to check whether they have misconceptions

Comparison of teachers' assessment literacy in knowledge level

Teachers will be compared considering assessment purposes, assessment strategies, what teachers assessed, and how teachers interpreted assessment and took action (Table 5). In terms of purposes, all teachers believed in using assessment for diagnostic, formative, and summative purposes. Determining students' achievement level of objectives was the main focus of all teachers' summative assessments. Grading was also prevalent among teachers. However, only one education major teacher (Oguz) considered its use for learning. Teachers were also similar in the sense that they planned to use diagnostic assessment for eliciting students' prior knowledge. With regard to formative assessment, education major teachers (Oguz and Ahu) were more knowledgeable about the ways that assessment could be used for formative purposes. Also, only these teachers had the idea of using formative assessment for determining students' learning level. Checking teaching during formative assessment was embraced by all education major teachers (Oguz and Ahu) and one science major (Miray) teacher. Interestingly, one education major (Oguz) and one science major (Miray) teacher believed in utilizing formative assessment for helping students to develop learning. Similarly, one education major (Oguz) and one science major (Sarp) shared the idea of using formative assessment for encouraging students to learn.

When teachers' assessment strategies were compared, it was revealed that education major teachers were more knowledgeable about formal assessment strategies, especially about alternative ones. All teachers stated that they used smartboard, examination, test (fill in the blanks, matching, true-false, and multiple-choice questions), questioning, homework, and lab reports as formal assessments. However, education major teachers had the idea of using advance organizers, classroom assessment, project, peer assessment, and group assessment. In terms of informal strategies, all teachers mentioned that they utilized teacher observation. All teachers except one, a science major (Miray), had the idea of using discussion.

Teachers were the same in terms of including factual, conceptual, and procedural knowledge in what to assess. Interestingly, nature of science was emphasized by one education major (Ahu) and one science major (Miray) teacher. Comparison of teachers' knowledge about assessment interpretation and action taking did not reveal any clear-cut differences among teachers with different majors. In general, all teachers were knowledgeable about using assessment results to collect data about students' learning, difficulties, and misconceptions. However, using assessment data to improve teaching and to improve students' learning through feedback were stated by all teachers except one, science major (Sarp).

Table 5.

Comparison of Participant Teachers' Assessment Literacy in Knowledge Level

Assessment literacy	Oguz (Education)	Ahu (Education)	Sarp (Science)	Miray (Science)
Assessment purpose	Summative • Determining students' achievement level of objectives • Grading for students' learning	Summative • Determining students' achievement level of objectives • Grading	Summative • Determining students' achievement level of objectives • Grading	Summative • Determining students' achievement level of objectives • Grading
	Diagnostic • Eliciting students' prior knowledge	Diagnostic • Eliciting students' prior knowledge	Diagnostic • Eliciting students' prior knowledge	Diagnostic • Eliciting students' prior knowledge
	Formative • Eliciting students' learning difficulties and misconceptions • Providing feedback to students by encouraging them to learn • Creating a context for students' learning • Helping students to develop their learning • Monitoring students' learning level • Checking teachers' teaching	Formative • Eliciting students' learning difficulties and misconceptions • Monitoring students' learning level • Providing feedback to students • Checking teachers' teaching	Formative • Eliciting students' learning difficulties and misconceptions • Encouraging students to learn	Formative • Eliciting students' misconceptions • Providing feedback to students • Helping students to develop their learning • Checking teachers' teaching
Assessment strategies	Formal • Smartboard • Examination • Test (fill in the blanks, matching, true-false, and multiple-choice questions) • Questioning • Homework • Lab reports • Advance organizer • Classroom assessment • Peer assessment • Group assessment	Formal • Smartboard • Examination • Test (fill in the blanks, matching, true-false, and multiple-choice questions) • Questioning • Homework • Lab reports • Advance organizer • Classroom assessment • Project	Formal • Smartboard • Examination • Test (fill in the blanks, matching, true-false, and multiple-choice questions) • Questioning • Homework • Lab reports	Formal • Smartboard • Examination • Test (fill in the blanks, matching, true-false, and multiple-choice questions) • Questioning • Homework • Lab reports • Warm-up questions
	Informal • Discussion • Teacher observation	Informal • Discussion • Teacher observation	Informal • Discussion • Teacher observation	Informal • Teacher observation
What to assess	• Factual knowledge • Conceptual knowledge • Procedural knowledge	• Factual knowledge • Conceptual knowledge • Procedural knowledge • Nature of science	• Factual knowledge • Conceptual knowledge • Procedural knowledge	• Factual knowledge • Conceptual knowledge • Procedural knowledge • Nature of science
Assessment interpretation and action-taking	Oguz stated that he uses assessment results to elicit students' prior knowledge, to determine students' difficulties and misconceptions, to provide feedback to students by encouraging them to learn, to create a context for students' learning, to help students to develop their learning, to monitor students' learning, to check his teaching, to help students to achieve objectives, to grade for students' learning during pre-interview.	Ahu stated that she uses assessment results to elicit students' prior knowledge, to determine students' difficulties and misconceptions, to determine students' learning level, to provide feedback to students, to check her teaching, to determine students' achievement level of objectives, and to grade during pre-interview.	Sarp stated that he uses assessment results to elicit students' prior knowledge, to determine students' difficulties and misconceptions, to encourage students to learn, to help students achieve objectives, and to grade during pre-interview.	Miray stated that she uses assessment results to elicit students' prior knowledge, to determine students' misconceptions, to provide feedback to students, to help students to develop their learning, to check her teaching, to help students to achieve objectives, and to grade during pre-interview.

Comparison of Teachers’ Assessment Literacy in Practice Level

Teachers' practices were compared considering assessment purposes, assessment strategies, what teachers assessed, and how teachers interpreted assessment and took action (Table 6). All teachers used summative assessment to determine students' achievement level of objectives. However, education major teachers utilized summative assessment to grade students' learning whereas science major teachers used it for grading. Three teachers (Oguz, Ahu, and Miray) elicited students' prior knowledge through summative assessment while one science major teacher (Sarp) did not perform the summative assessment for that purpose. In terms of formative assessment, all teachers elicited students' misconceptions and difficulties, provided feedback to students, and checked their teaching. However, education major teachers utilized formative assessment for a wider range of purposes than science teachers did and for ensuring students' learning as well. Monitoring students' learning level and checking teaching purposes came together only in education major teachers’ practices.

When teachers were compared in terms of strategies, it was revealed that all teachers used smart board, examination, test (fill in the blanks, matching, true-false, and multiple-choice questions), questioning, and homework as formal assessments. Nevertheless, education major teachers utilized more variety of methods, especially alternative ones (e.g., advance organizer and peer assessment), than science majors did. All participating teachers used teacher observation as an informal strategy.

Teachers were similar to each other in the sense that they all assessed factual, conceptual, and procedural knowledge. Interestingly, one education major (Ahu) and one science (Miray) teacher focused on assessing nature of science during their practices.

Teachers' assessment practices in terms of how they interpreted assessment results and took action did not differ to a certain degree. All participating teachers used assessment results to get information regarding students' learning in terms of objectives, difficulties, and misconceptions. Moreover, all teachers provided feedback to students and checked their teaching. However, science major teachers' feedbacks were not as good as education major teachers' in terms of informing and supporting students' learning. Their feedback included saying "right and wrong" to students' responses. One education major teacher, Oguz, among others utilized assessment results for a wide variety of ways than other teachers did.

Table 6.

Comparison of Participant Teachers' Assessment Literacy in Practice Level

Assessment literacy	Oguz (Education)	Ahu (Education)	Sarp (Science)	Miray (Science)
Purpose	Summative • Determined students' achievement level of objectives • Graded for students' learning	Summative • Determined students' achievement level of objectives • Graded for students' learning	Summative • Determined students' achievement level of objectives • Graded	Summative • Determined students' achievement level of objectives • Graded
	Diagnostic • Elicited students' prior knowledge	Diagnostic • Elicited students' prior knowledge	Diagnostic	Diagnostic • Elicited students' prior knowledge
	Formative • Elicited students' learning difficulties and misconceptions • Provided feedback to students by encouraging them to learn • Created context for students' learning • Helped students to develop their learning • Monitored students' learning level • Checked teaching • Encouraged students' peer and self-learning	Formative • Elicited students' learning difficulties and misconceptions • Monitored students' learning level • Provided feedback to students • Checked teaching	Formative • Elicited students' learning difficulties and misconceptions • Provided feedback to students • Checked teaching	Formative • Elicited students' learning difficulties and misconceptions • Provided feedback to students • Checked teaching
Strategies	Formal • Smartboard • Examination • Test (fill in the blanks, matching, true-false, and multiple-choice questions) • Questioning • Homework • Lab reports • Advance organizer • Classroom assessment • Peer assessment • Group assessment	Formal • Smartboard • Examination • Test (fill in the blanks, matching, true-false, and multiple-choice questions) • Questioning • Homework • Advance organizer • Classroom assessment	Formal • Smartboard • Examination • Test (fill in the blanks, matching, true-false, and multiple-choice questions) • Questioning • Homework	Formal • Smartboard • Examination • Test (fill in the blanks, matching, true-false, and multiple-choice questions) • Questioning • Homework • Warm-up questions
	Informal • Teacher observation	Informal • Teacher observation	Informal • Teacher observation	Informal • Teacher observation
What to assess	• Factual knowledge • Conceptual knowledge • Procedural knowledge	• Factual knowledge • Conceptual knowledge • Procedural knowledge • Nature of science	• Factual knowledge • Conceptual knowledge • Procedural knowledge	• Factual knowledge • Conceptual knowledge • Procedural knowledge • Nature of science
Assessment interpretation and action-taking	Oguz used assessment results to elicit students' prior knowledge, to determine students' difficulties and misconceptions, to provide feedback to students by encouraging them to learn, to create a context for students' learning, to encourage students' peer and self-learning, to help students to develop their learning, to check his teaching, to help students to achieve objectives, to grade for students' learning during his teaching.	Ahu used assessment results to elicit students' prior knowledge, to determine students' difficulties and misconceptions, to determine students' learning level, to provide feedback to students, to determine students' achievement level of objectives, and to grade for students' learning during her teaching.	Sarp used assessment results to determine students' difficulties and misconceptions, to provide feedback to students, to check his teaching, to help students achieve objectives, and to grade during his teaching.	Miray used assessment results to elicit students' prior knowledge, to determine students' learning difficulties and misconceptions, to provide feedback (i.e., yes and no) to students, to check her teaching, to help students to achieve objectives, and to grade during her teaching.

Discussion

Findings were discussed considering teachers’ perception of assessment influenced by their views of learning first and then teachers’ assessment literacy in knowledge and practice level.

Teachers' views of learning included several dimensions. With respect to goals for teaching, education major science teachers' goals were subject matter goals (i.e., teaching science) whereas science major teachers' goals were schooling (i.e., preparation for life). This finding is compatible with the nature of teachers' orientation indicating that teachers have a variety of goals such as schooling, affective, and subject matter (Friedrichsen & Dana, 2005). Differences between teachers with different majors might be related to the differences in their undergraduate education (Avraamidou, 2013; Mansoor, 2009). Teacher education programs' focus is "teaching science knowledge meaningfully to students" while the focus of the program in arts and science faculty is "contributing to use of science knowledge for research and industrial purposes". Differences in the focuses of programs might provide a baseline for how they interpret their experiences (Mansour, 2009) and how they see their profession (Friedrichsen & Dana, 2005). Participants with different majors were also different from each other in terms of their views about teacher roles. Education major teachers embraced the role of a guide during learning whereas science major teachers believed that their role was to help students' development of positive attitudes towards science. This difference might also be explained by knowledge and experiences that they gained during undergraduate education (Avraamidou, 2013; Mansoor, 2009), which has the potential to influence how teachers see their profession (Friedrichsen & Dana, 2005). Teachers' goals for teaching were compatible with their role during teaching, which is consistent with the fact that teachers' orientation is an interrelated set of beliefs (Friedrichsen, van Driel & Abell, 2011). In terms of students roles, there was no difference between teachers with different majors. All teachers stated that students should be active during learning. This finding is expectable considering the fact that participating teachers have taught science based on a national science curriculum (Ministry of National Education, 2018) adopting constructivism (Friedrichsen & Dana, 2005). There was a discernible difference in the teaching sequence of teachers with different majors. Education major teachers were better at designing instruction that ensured student-learning than science majors did. This might be stemmed from differences in teachers’ pedagogical content knowledge. Pedagogical content knowledge is the knowledge that ensures teachers' teaching of the topic in a way that is understandable by students (Shulman, 1986). Courses taken during teacher education are one of the major sources for pedagogical content knowledge development (Grossman, 1990). Although teachers were not so much different from each other in terms of their teaching experience, another source of pedagogical content knowledge (Abell, 2007), courses taken at education faculty by education major teachers might constitute a baseline for their professional development (Demirdogen, Hanuscin, Uzuntiryaki-Kondakci & Koseoglu, 2016). With respect to perception, all teachers considered assessment as a tool for eliciting students' prior knowledge. Similarity between teachers might be explained by teachers' teaching science based on a national science curriculum (Sen, Oztekin & Demirdogen, 2018), which has spiral nature, and curriculum is one of the factors affecting teachers' assessment decisions (Tomanek, Talanquer & Novodvorsky, 2008). However, perceiving assessment as a way to reveal students' misconceptions was only observed in education major teachers. This might be explained by the interaction between "knowledge of learner" and "knowledge of assessment" components of pedagogical content knowledge (Aydin, Demirdogen, Akin, Uzuntiryaki-Kondakci & Tarkin, 2015; Demirdogen et al., 2016), which might be strengthened by courses during taken teacher education (Bell & Cowie, 2001; Grossman, 1990) and subsequent teaching experience (Abell, 2007).

Teachers' assessment literacy was discussed considering its components (e.g., purposes and strategies). Teachers were not different from each other in terms of the type of assessment purposes that existed in knowledge and practice level. That is, they all understood and enacted assessments for diagnostic, formative, and summative purposes. Teaching experience (i.e., at least 20 years of experience) might influence science major teachers' pedagogical professional knowledge (Abell, 2007) and assessment practices (Tomanek et al., 2008), and hence they might have the same purposes as education major teachers. However, how teachers translated their purposes into practice was different for education and science major teachers. Grading and determining students' achievement level of objectives existed in all participating teachers' summative purposes in both knowledge and practice level. This finding is compatible with the finding of other studies in the literature (Nazlıçiçek & Akarsu, 2008; Volante & Fazio, 2007). Teachers' having summative purposes in knowledge and practice level might be related to the fact that teachers feel responsible for ensuring students' both objective achievement and being successful at state-wide exams (Bell & Cowie, 2001; Tomanek et al., 2008). However, only one education major teacher (Oguz) perceived and enacted summative assessment as a means to grade learning, which might be related to the nature of that teacher's pedagogical professional knowledge base. Oguz had nine years of teaching experience and courses that he took during teacher education were mostly influenced by constructivism, which might influence his assessment knowledge and practice (Grossman, 1990). In terms of diagnostic assessment, all teachers except one (science major teacher, Sarp) transfered their purpose of eliciting prior knowledge to their practices. The gap in teachers' beliefs and practices might be the reason for Sarp's inability to transfer that purpose to practice (Demirdogen et al. 2016; Uzuntiryaki, Boz, Kirbulut & Bektas, 2010). Moreover, Sarp did not define his role as a guide during teaching and preferred to lecture after informing students about the objectives. Sarp's views of learning might affect both his purposes (Abell & Siegel, 2011) and practices (Bell & Cowie, 2001) of assessment. Interestingly, all participating teachers were able to transfer all of their formative assessment purposes to their practices, which is in line with the studies indicating that teachers have formative assessment practices (Ruiz-Promo & Furtak, 2007). This is also compatible with the fact that teachers' pedagogical professional knowledge has both understanding and enactment dimensions (Park & Chen, 2012). Teacher education courses (Bell & Cowie, 2001; Grossman, 1990), teaching experience (Abell, 2007; Box, 2008), and curriculum (Tomanek et al., 2008) might result in the observation of formative assessment practices in all teachers. However, the quality of teachers' formative assessment practices differed; science major teachers' feedbacks provided for students' learning were observed as "right and wrong". Education major teachers encouraged students learn from peers when providing feedback. Since science major teachers did not take any course on assessment, their poor formative assessment practices were expectable (Bell & Cowie, 2001).

Teachers mostly preferred to use formal assessment strategies in both knowledge and practice level, which is compatible with the studies indicating that teachers favor traditional assessment since they might feel knowledgeable about those (Gelbal & Kelecioğlu, 2007), responsible for preparing students for statewide exams (Black & Wiliam, 2004; Box, 2008), and have low self-efficacy about formative assessment (Box, 2008; Gelbal & Kelecioğlu, 2007). However, education major teachers used advance organizers and classroom assessment during teaching as opposed to science teachers. Teacher education courses (Bell & Cowie, 2001; Grossman, 1990) and teaching experience (Abell, 2007; Box, 2008) might explain this difference.

With regard to what to assess, all teachers believed in assessing factual, conceptual, and procedural knowledge and assessed those in practice. This is expectable considering the fact that curriculum (Tomanek et al., 2008) and feelings responsible for preparing students for statewide exams (Bell & Cowie, 2001; Box, 2008; Tomanek et al., 2008) influence teachers' assessment practices.

Teachers' assessment knowledge and practices in terms of how they interpreted assessment results and took action did not differ to a certain degree. In general, all teachers used assessment results to collect data about students' learning in terms of objectives, difficulties, and misconceptions as they stated during pre-interview. Furthermore, all participating teachers were able to provide feedback to students and check their teaching. Nevertheless, science major teachers' feedbacks were not qualified enough to inform and enhance students' learning. Also, one education major teacher, Oguz, among others utilized assessment results for a wide variety of ways than other teachers did. Education major teachers might have more developed pedagogical content knowledge than science majors might have (Aydin et al., 2015; Demirdogen et al., 2016; Shulman, 1986) because of teacher education courses (Bell & Cowie, 2001; Grossman, 1990) and teaching experience (Abell, 2007; Box, 2008).

Implications for Research and Teacher Education

The findings of the study have implications for teacher education and research. Science teachers' assessment literacy, one of the components of pedagogical professional knowledge of teachers, is implicit (Loughran et al., 2004) and complex (Abell & Siegel, 2011) in nature. Therefore, teacher education courses and professional development programs should provide opportunities where pre-service and in-service teachers think about their assessment knowledge in an explicit and reflective manner. Therefore, these contexts should encourage pre and in-service teachers to provide their answers to the questions of "Why do I conduct assessment during teaching? What are my purposes for assessment? To what degree my assessment purposes and views of learning are compatible? How do I interpret assessment results? Do I use evaluation to improve teaching and learning?" Science method and practicum courses have the potential for helping pre-service teachers to create their answers to these questions. In-service teachers also need professional development programs, as they stated during the study, which aim to increase both their knowledge and practices of assessment and evaluation.

This study has been one of the first attempts investigating education and science major teachers' assessment literacy within the context of teaching "Matter and its Change" unit at public schools. Teachers' subject matter knowledge and contexts of teaching might influence their assessment knowledge and practices (Magnusson et al., 1999). Therefore, there is a need to conduct studies with teachers both having different levels of subject matter knowledge and teaching in different contexts (i.e., private versus public). Another research might be the determination of science teachers' assessment literacy enacted during the teaching of different disciplines of science (e.g., physics and biology). These kinds of studies might contribute to understanding the nature of science teachers' assessment literacy.

References

Abell, S. K. (2007). Research on science teacher knowledge. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 1105–1151). Mahwah, NJ: Lawrence Erlbaum.

Abell, S. K., & Siegel, M. A. (2011). Assessment literacy: What science teachers need to know and be able to do. In D. Corrigan, J. Dillon, & R. Gunstone (Eds.), *The Professional knowledge base of science teaching* (pp. 205-221). Dordrecht: Springer.

Akdag-Gursoy, G. (2015). *Influence of the course of practical assessment and evaluation associated with the field on the literacy levels of assessment and evaluation attitudes and content knowledge of teacher candidates* [Unpublished Doctoral Dissertation]. Gazi University.

Avraamidou, L. (2013). Prospective elementary teachers' science teaching orientations and experiences that impacted their development. *International Journal of Science Education, 35*(10), 1698-1724. https://doi.org/10.1080/09500693.2012.708945

Aydin, S., Demirdogen, B., Akin, F. N., Uzuntiryaki-Kondakci, E., & Tarkin, A. (2015). The nature and development of interaction among components of pedagogical content knowledge in practicum. *Teaching and Teacher Education, 46*, 37–50. https://doi.org/10.1016/j.tate.2014.10.008

Bell, B., & Cowie, B. (2001). *Formative assessment and science education.* Dordrecht, Boston: Kluwer Academic.

Black, P. & Wiliam, D. (2004) The formative purpose: assessment must first promote learning. In M. Wilson (Eds.) *Towards coherence between classroom assessment and accountability: 103rd yearbook of the national society for the study of education* (2nd ed., pp. 20-50), Chicago, IL: University of Chicago Press.

Box, C. (2008). *Formative Assessment: Patterns, personal practice assessment theories, and impact on student achievement and motivation in science* [Unpublished Doctoral Dissertation]. Texas Tech University.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, D.C.: National Academy Press.

Buldur, S. (2009). *Developing Literacy and Self-Efficacy Levels of Science Teacher Candidates toward Alternative Assessment Approaches* [Unpublished Master's Thesis]. Sivas Cumhuriyet University.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Davidheiser, S. A. (2013). *Identifying Areas for High School Teacher Development: A Study of Assessment Literacy in the Central Bucks School District* [Unpublished Doctoral Dissertation]. Drexel University.

DeLuca, C., Chavez, T., Bellara, A., & Cao, C. (2013). Pedagogies for preservice assessment education: Supporting teacher candidates' assessment literacy development. *The Teacher Educator, 48*(2), 128-142. https://doi.org/10.1080/08878730.2012.760024

DeLuca, C., LaPointe-McEwan, D., & Luhanga, U. (2016). Teacher assessment literacy: A review of international standards and measures. *Educational Assessment, Evaluation and Accountability, 28*(3), 251-272. https://doi.org/10.1007/s11092-015-9233-6

Deneen, C. C., & Brown, G. T. (2016). The impact of conceptions of assessment on assessment literacy in a teacher education program. *Cogent Education, 3*(1), 1-14. https://doi.org/10.1080/2331186X.2016.1225380

Demirdogen, B., Hanuscin, D. L., Uzuntiryaki-Kondakci, E., & Koseoglu, F. (2016). Development and nature of preservice chemistry teachers' pedagogical content knowledge for nature of science. *Research in Science Education, 46*(4), 575-612. https://doi.org/10.1007/s11165-015-9472-z

Fraenkel, J. R., & Wallen, N. E. (2006). *How to design & evaluate research in education* (6th ed.). Boston: McGraw-Hill.

Friedrichsen, P., & Dana, T. (2005). A substantive-level theory of highly regarded secondary biology teachers' science teaching orientations. *Journal of Research in Science Teaching, 42*, 218–244. https://doi.org/10.1002/tea.20046

Friedrichsen, P., van Driel, J. H., & Abell, S. K. (2011). Taking a closer look at science teaching orientations. *Science Education, 95*, 358–376. https://doi.org/10.1002/sce.20428

Gelbal, S., & Kelecioğlu, H. (2007). Teachers' proficiency perceptions of about the measurement and evaluation techniques and the problems they confront. *Hacettepe University Journal of Education, 33*(33), 135-145. http://www.efdergi.hacettepe.edu.tr/shw_artcl-1017.html

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago: Aldine.

Gottheiner, D. M. & Siegel, M. A. (2012). Experienced middle school science teachers' assessment literacy: investigating knowledge of students' conceptions in genetics and ways to shape instruction, *Journal of Science Teacher Education, 23*(5), 531-557. https://doi.org/10.1007/s10972-012-9278-z

Grossman, P. (1990). *The making of a teacher.* New York, NY: Teachers College Press.

Gul, E. (2011). *Preservice elementary teachers assessment literacy and attitude towards assessment* [Unpublished Master Thesis]. Fırat University.

Izci, K. (2018). Secondary science teachers' assessment literacies in Turkey: A descriptive content analysis. *Journal of Education and Humanities: Theory and Practice, 9*(17), 23-54. https://dergipark.org.tr/en/download/article-file/513964

Izci, K. & Siegel, M. A. (2019). Investigation of an alternatively certified new high school chemistry teacher's assessment literacy. *International Journal of Education in Mathematics, Science and Technology, 7*(1), 1-19. doi: 10.18404/ijemst.473605

Koh, K. H. (2011). Improving teachers' assessment literacy through professional development, *Teaching Education, 22*(3), 255-276. https://doi.org/10.1080/10476210.2011.593164

Levy-Vered, A. & Nasser-Abu Alhija, F. (2015). Modeling beginning teachers' assessment literacy: The contribution of training, self-efficacy, and conceptions of assessment, *Educational Research and Evaluation, 21*(5-6), 378-406. https://doi.org/10.1080/13803611.2015.1117980

Loughran, J., Mulhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching, 41*, 370–391. https://doi.org/10.1002/tea.20007

Magnusson, S. J., Borko, H. & Krajcik, J. S. (1999). Nature, source, and development of pedagogical content knowledge for science teaching. In J. Gess- Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp.95-132). Boston, MA: Kluwer Press.

Mansour, N. (2009). Science teachers' beliefs and practices: Issues, implications and research agenda. *International Journal of Environmental and Science Education, 4*(1), 25-48. https://files.eric.ed.gov/fulltext/EJ884384.pdf

Marshall, G. B., & Rossman, C. (2011). *Designing qualitative research* (5th ed.). London: Sage.

Merriam, S. B. (2002). *Qualitative research in practice: Examples for discussion and analysis*. Hoboken, NJ: Wiley.

Mertler, C. A. (2005). Secondary teachers' assessment literacy: does classroom experience make a difference?. *American Secondary Education, 33*(1), 49-64. http://www.jstor.org/stable/41064623

Ministry of National Education. (2018). *Middle Schhol Science Curriculum (Fen Bilimleri Dersi Öğretim Programı)*. Ankara: Milli Eğitim Bakanlığı. http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=325

Nazlicicek, N., & Akarsu, F. (2008). Physics, chemistry and mathematics teachers approaches to assessment tools and their assessment practices, *Education and Science, 33*(149), 18-29. http://egitimvebilim.ted.org.tr/index.php/EB/article/view/637

Ogan-Bekiroglu, F., & Suzuk, E. (2014). Pre-service teachers' assessment literacy and its implementation into practice. *Curriculum Journal, 25*(3), 344-371. https://doi.org/10.1080/09585176.2014.899916

Park, S., & Chen, Y. C. (2012). Mapping out the integration of the components of pedagogical content knowledge (PCK): Examples from high school biology classrooms. *Journal of Research in Science Teaching, 49*, 922–941. https://doi.org/10.1002/tea.21022
Patton M. Q., (2002). *Qualitative research and evaluation methods*, 3rd ed., Thousand Oaks, CA: Sage.
Quilter, S. M., & Gallini, J. K. (2000). Teachers' assessment literacy and attitudes. *The Teacher Educator, 36*(2), 115-131. https://doi.org/10.1080/08878730009555257
Ruiz-Primo, M. A., & Furtak E. M. (2007). Exploring teachers' informal formative assessment practices and students' understanding in the context of scientific inquiry. *Journal of Research in Science Teaching, 44*(1), 57. https://doi.org/10.1002/tea.20163
Shepard, L. A. (2000). The role of assessment in a learning culture. *Educational Researcher, 29*(7), 4–14. https://doi.org/10.3102/0013189X029007004
Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14. https://doi.org/10.3102/0013189X015002004
Siegel, M. A., & Wissehr, C. (2011). Preparing for the plunge: Preservice teachers' assessment literacy. *Journal of Science Teacher Education, 22*(4), 371-391. https://doi.org/10.1007/s10972-011-9231-6
Stiggins, R. J. (1991). Assessment literacy. *Phi Delta Kappan, 72*(7), 534-539.
Stiggins, R. J. (1999). Evaluating classroom assessment training in teacher education programs. *Educational Measurement: Issues and practice, 18*(1), 23-27. https://doi.org/10.1111/j.1745-3992.1999.tb00004.x
Stiggins, R. J. (2002). Assessment crisis: The absence of assessment for learning. *Phi Delta Kappan, 83*(10), 758–65. https://doi.org/10.1177/003172170208301010
Sen, M., Oztekin, C. & Demirdogen, B. (2018). Impact of content knowledge on pedagogical content knowledge in the context of cell division, *Journal of Science Teacher Education, 29*(2), 102-127. https://doi.org/10.1080/1046560X.2018.1425819
Tomanek, D., Talanquer, V., & Novodvorsky, I. (2008). What do science teachers consider when selecting formative assessment tasks?. *Journal of Research in Science Teaching Teaching, 45*(10), 1113-1130. https://doi.org/10.1002/tea.20247
Uzuntiryaki, E., Boz, Y., Kirbulut, D., & Bektas, O. (2010). Do pre-service chemistry teachers reflect their beliefs about constructivism in their teaching practices?. *Research in Science Education, 40*(3), 403-424. https://doi.org/10.1007/s11165-009-9127-z
Volante, L., & Fazio, X. (2007). Exploring teacher candidates' assessment literacy: Implications for teacher education reform and professional development. *Canadian Journal of Education 30*(3), 749–70. https://files.eric.ed.gov/fulltext/EJ780818.pdf
Xu, Y., & Brown, G.T. (2016). Teacher assessment literacy in practice: A reconceptualization. *Teaching and Teacher Education, 58*(1), 149-162. https://doi.org/10.1016/j.tate.2016.05.010
Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage.

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Appendix A: Selected Interview Questions

Pre-Interview

Views about Learning

1. What is the purpose of science education?
2. What is the purpose of your teaching?
3. What are your roles as a teacher during teaching?
4. What are students' roles during teaching?
5. How does learning occur?
6. How do your views about learning affect your assessment decisions and strategies?

Perception, Knowledge, and Practices of Assessment

1. What is your personal opinion about assessment? Do you think that assessment is useful for teaching?
2. What do you know about assessment?
    a. Where did you learn about assessment? (e.g., teacher education, professional development, colleagues, curriculum, and own interest)
3. What are your assessment purposes?
4. What are various ways that you use during an assessment?
5. What are the most frequent assessment strategies that you used during your teaching?
    a. How do you select, plan and use those strategies?
6. How do you as a teacher interpret assessment results?
7. How do students interpret assessment results?

Post-interview

1. What was the purpose of using……….assessment strategy? What would you plan to achieve?
2. What was the reason for using the……….assessment strategy?
3. How did you use the data that you obtained from……….assessment strategy
4. Did……….assessment strategy provide enough information about students' learning?
5. Will you use……….assessment strategy again?

Appendix B: Observation Protocol

Instructor:
Date:
School Name:
Lesson Topic:
Class Period Observed:
Student Demographics:
Classroom Layout (lab/classroom):

Time	Description-Focus on the following criteria: • Clarity of learning goals and criteria for success • Use of effective classroom assessment (e.g., Questioning, discussion, concept mapping) • Use and types of feedback that focuses on learning • Activating students as the owners of learning • Activating students for peer and self-learning	Reflection of the researcher based on theoretical aspects of assessment literacy
At the beginning of class		
During class		
At the end of class		