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Analysis of Differences in Academic Achievement based on the Level of Learner Questioning in an Online Inquiry Learning Environment

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It is crucial to understand the characteristics of learner questioning due to the effects it has on learning. This study focuses on the effects of middle school students questioning on their academic achievement in an online inquiry learning environment. A survey of 827 middle school students was conducted; the students took part in an online math and science program offered by a center for the gifted. Throughout the survey, learner questioning was analyzed, and its correlation with academic achievement was investigated. An analysis was based on questioning categories of a low- and high-level questions from previous studies. Through the survey, it was found that the number of learner questions asked in the online environment was small, but the number of low- and high-level questions were almost equal. Secondly, the higher the academic achievement level of the student, the higher the possibility they would ask either low- or high-level questions. Lastly the group of students in both low- and high-levels of questioning earned the highest average scores on formative evaluations and inquiry tasks. This indicates that regardless of the level of questions, the act of questioning itself is highly related to the academic achievement. However, in the case of advanced learning projects, the quality of questioning and high-level questioning affected the academic achievement of students. Based on these results, implications for the encouragement of learner questioning and support for asking high-level question are suggested.

Keywords: Learner Questioning, Questioning Level, Online Inquiry Learning, Academic Achievement

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Introduction

Thorough and rich interaction is a guide to meaningful learning experiences. Therefore, interaction is often a good criterion of the quality of education. Questioning between learners and teachers is the fundamental activity of interaction in classes (Hill, 2016). Questioning also accelerates interaction among learners (Kim, 2015; Lee, 2001).

In addition, questioning is considered one of the strongest tools to expedite higher order thinking (Hill, 2016). This is due to learner participation in seeking the answer through questioning. Specifically, questioning is effective for self-directed learning, problem-solving, and various thinking skills such as creative thinking, critical thinking, and metacognitive ability.

However, numerous teachers and learners hesitate to ask questions (Graesser & Person, 1994). Especially in a Korean context, questioning is lacking in classes (Woo, Yoo, & Park, 2015). Sociocultural background explains the phenomenon, but there is a growing necessity of a strategy for prompting questioning in classes. (Chung & Bae, 2002; Lee, 2012). In this sense, many proposals are being made through research.

Until now, researchers have focused on teacher questioning rather than learner questioning by learners (Jeon, 2010). For instance, there are studies on levels of questions asked by teachers in science classes and their impact on student participation (Bilaoglu, Arnas, & Yasar, 2017), and quality of teachers' questions (Qashoa, 2013). Active questioning by learners is crucial since it can induce thorough and engrossed education, however questioning by learners has not been thoroughly dealt with (Eason, 2000; Park, 2006).

Most of the research so far on the effect of question taxonomy dealt with teacher questions. Those studies either categorized questions according to the taxonomy of education objectives by Bloom (1956) (Blosser, 2000; Chin, 2007; Krathwohl, 2002; Qashoa, 2013; Tofade, Elsner, & Haines, 2013; Wolfinger, 2000), or analyzed strategic approaches for teachers to promote active thinking in learners (Bilaoglu, Arnas, & Yasar, 2017; Critelli & Tritapoe, 2010).

Studies on learner questioning mainly focused on the effectiveness of learner questioning and strategies to learner questioning (Chung & Bae, 2002; Moon, & Cha, 2013; Lee, 2002; Woo, Kim, & Yeo, 1999a). These studies reported that learner questioning was positively associated with learner achievement and understanding. In addition, a learner's level of questioning was enhanced by questioning reinforcement strategies. Most of these studies are limited to the context of a classroom, however; learners' questioning in online learning is more emphasized. In the online learning environment, learner questions have been mainly studied in relation to interaction. Studies of learner interaction in online learning have concerned the relationship between learner interaction and learning results, and strategies to promote learner interaction. (Kwon, 2009; Choi & Choi, 2016; Choi, 2008; Lim, Park, & Song, 2006; Jeon & Cho, 2017). In previous studies, learner questions have been dealt with within the context of learner-teacher interaction or learner-learner interaction, and thus learner questions were considered part of the various messages generated by learners during online learning. Few studies have focused on the learner's question itself. Thus, there is a lack of knowledge regarding the effects of levels of learner questions by learners on academic achievement in an online learning environment.

This study focuses on the effect of learner questioning on academic achievement in online classes. In order to do so, the following three research questions have been set.

First, what is the frequency and level of questioning by middle school students in an online inquiry learning environment?

Second, what is the level of questioning done by students at different levels of academic achievement in an online inquiry learning environment?

Third, what is the difference in academic participation and achievement based on the level of questioning in an online inquiry learning environment?

Learner's Questioning

Questioning in learner-centered education

Learner questioning

Two general approaches to learner questioning were taken by researchers; 1) the effect of learner questioning on learning ability, and 2) ways to reinforce learner questioning.

First, it has been reported that learner questioning affects their academic achievement or critical thinking. For example, Lee (2002) studied the effects of peer questioning rather than teacher questioning on the development of academic achievement or critical thinking. Moon & Cha (2013) demonstrated that learner question generation can increase concept understanding in classes. Learners generate questions based on their experience and prior knowledge that will result in an increase in concept understanding. They also tried to figure out the effect of question generation, student connection with the text, and the level of the student's prior knowledge on their understanding of a high school textbook. The questions were divided into divergent and convergent questions. Results showed that reading groups with both divergent and convergent questions showed higher scores in understanding the core context, and recalled important events in the text. However, there was no statistically significant difference between the divergent question group and the convergent question group. Researchers concluded that this is perhaps due to a cognitive burden to produce divergent questions which led to interference in understanding core context.

Secondly, studies on reinforcing learner questioning have been conducted. Although it was perceived that learner-centered questioning is crucial, there is still a lack of student questioning in the classroom (Graesser & Person, 1994). Researchers have established the necessity for teachers to develop strategies to support and develop learner's question generation (Chung & Bae, 2002). According to Chung & Bae (2002) question enhancement classes have an impact on the level of questioning and academic achievement. A survey of middle school students showed that there was a rise in the level of questioning as well as improvement of academic achievement. Likewise, Woo et al. (1999a) validated the concept of higher understanding through questioning reinforcement.

In addition, learner questioning gives a glimpse of how learners understand the class, whether they are confused, or if there is insufficient information to understand the concept. Thus, it is considered useful when designing or managing a class (King, 1994; Maskill & Pedrosa de Jesus, 1997; White & Gunstone, 1992; Woo, Kim, & Yeo, 1999b)

Effect of questioning

Questioning is essential in teaching and learning activities (Hill, 2016). Several recent studies show the effects of questioning in classes. Questioning allows learners to have deeper understanding of new concepts or foreign language materials (Berkeley, Marshak, Mastropieri, & Scruggs, 2011), or improve reading skills of students who lack those skills (Berkeley, Mastropieri, & Scruggs, 2008). In addition, questioning enables effective student learning by allowing them to analyze and compare through inquiry-based problem solving, thereby leading to higher order thinking (Hill, 2016). Self- directed learning, problem solving (Park & Woo, 2017), and metacognitive ability development (Bang & Choi, 2016) are also possible. Questioning leads to creative problem solving, enhanced creativity, and critical thinking (Choi & Park, 2003; Shin & Han, 2003).

Question strategy or question enhancement are being emphasized in current research based on the educational effects of questioning in teaching and learning activities (Chung & Bae, 2002). These studies either limit questioning to a memorization tool or suggest questioning only as an aspect of classroom management. For instance, Lee (2012) categorized levels of teachers' questions in elementary science classes. It was found that teachers asked low-level questions such as management questions, simple verification questions, and repetitive questions. There were neither enough productive questions nor higher order thinking questions to promote scientific thinking skills or creative problem solving.

Researchers found that teacher questions were inadequate in developing student thinking skills. Rather, they required merely low cognitive skills (Chin, 2000; Choi, Ji, 2006; Lee, 2012). Researchers concluded that effective questioning by teachers would make classes more focused on activating student thinking (Chin, 2000; Choi & Park, 2003; Jeong, 2010; Kang, 2009; Shin & Han, 2003).

Shin & Han (2003) analyzed the relationship between teacher questioning and language creativity improvement among students to figure out the effects of levels of questions. Groups with divergent questions and groups with convergent questions showed differences in fluency and creativity. Similarly, Choi & Park (2003) demonstrated that students with open questions showed higher language expressions and thinking skills than students with closed questions. Such results indicate questions do affect the level of student learning ability.

Other than the level of questions such as simple memorization or tool for class management, most studies limit their boundaries to teacher questions rather than learner questions. Questions in classes can be divided into 1) teacher asking-teacher answering, 2) teacher asking-student answering, 3) student asking-peer answering, 4) student asking-self answering, and 5) student asking-teacher answering. However, the number of studies on teacher question is four times higher than that of learner question (Jeon, 2010).

Teacher questions tend to show an emphasis on the results of the thinking, or to fulfill the needs of the teachers, i.e., to provoke thinking, to verify understanding, to gain attention, and to manage a class. In this sense, teacher questions were inadequate in advancing students' thinking skills (Singer & Donlan, 1982). As humans are likely to understand and remember better if they have raised the questions themselves (Eason, 2000), student-oriented questioning is essential in the classroom (Park, 2006).

Level of questions

Several researchers have assumed that there will be a difference in the subject's thinking process and learning effectiveness according to the levels of questions the subject raised. For instance, according to research on the effect of level of teacher questioning (high-level questions and low-level questions) in science activities on student participation (Bilaoglu, Arnas, & Yasar, 2017), showed that all 6 teachers working with 6-year-old students asked low-level questions with less focus on student responses and didn't give students enough time to reflect on the question. Along with the studies of Bilaoglu, Arnas & Yasar (2017), many other studies have focused on the levels of questions asked by students.

Thus far, most of the research on the effect of question taxonomy have dealt with teacher questions. Those studies categorized questions according to the quality or level of questions, similar to the process taken in the taxonomy of education objectives by Bloom (1956) (Blosser, 2000; Qashoa, 2013). The 6 classes in levels of thinking based on understanding and application of knowledge were summarized into low-level questions and high-level questions (Bilaoglu, Arnas & Yasar 2017; Chin, 2007; Krathwohl, 2002; Tofade, Elsner, & Haines, 2013; Wolfinger, 2000). Low-level questions tend to ask for simple recall or memorization, while high-level questions allow learners to analyze, compare, and implicate relationships between concepts using the information, and come to a conclusion (Bilaoglu, Arnas, & Yasar, 2017; Critelli & Tritapoe, 2010).

Some other researchers even specified high-level questions as fact questions that allow understanding and application, and high-cognitive questions with analysis, summary, and evaluation of the thinking process (Gall, 1970; King, 1994; Sinatra & Annacone, 1984). Sadker & Cooper (1974) made two categories, low-level questions that can be answered based on recall, and high-level questions that require problem solving through causal relationships. Ellis (1991) and Wilen (1991) also showed the dichotomy between low-level questions with convergent thinking and high-level questions with creative and divergent thinking.

Other than these two levels of questions, White & Gunstone (1992) further categorized question levels into recall, reframe, application, and extension. Woo et al. (1999b) redefined recall as re-illustration of a concept, reframe as case representation, application as concrete application, verification of example, discrepancy in opinion, and alternative model suggestion, and lastly, extension as additional concept or proposal of meta concepts.

Woo et al. (1999a) suggested that learner questions portray the learner's learning process. For instance, a recall question indicates little or no acquisition of knowledge, while a reframe question shows rudimentary understanding with little application. Based on the two categories by other researchers, recall questions fall into the low-level question category, while other question levels are relatively close to being high-level questions.

To sum up, levels of learner questions generally fall into low-level questions and high-level questions. Low-level questions require realistic and limited answers such as recalling the concept, while high-level questions allow learners to develop answers through the process of analyzing, comparing, and applying.

Most studies have investigated the relationships between the level of instructor's questioning and students' learning achievement, rather than learner questioning levels. In addition, few research studies related to the level of questioning and learning effects have been conducted in the online setting. Woo, Kim & Bu (2012) showed that learner questioning activities positively related to their grades and class evaluation scores at a cyber university, but the researchers did not consider the levels of questions in that study. Also, Kwon (2009) investigated the relationship between learners' questioning and their learning achievement. The result indicated that more questions and more learning content-related questions positively related to their learning achievement. Although those two studies focused on revealing the relationship between learners' questioning and their learning achievement, to understand the relationship deeply, more various samples or sophisticated data would be needed; both studies included only university level students as their samples, and the data of studies was not classified by the level of questioning, either.

Method

Context of research

In this study, middle school students who took part in online-based math and science classes offered by K University were studied. Online classes were open to middle and high school students across the country. Students studied Math, Physics, Chemistry, and Biology based on the Korean national curriculum for 7th graders to 11th graders. The online classes provided middle and high school students with opportunities to learn mathematics and science concepts and engage in inquiry-based tasks to apply what they have learned. Throughout the twelve weeks course, eight core concepts were studied and two inquiry-based tasks which were developed for scientific inquiry into everyday real-world problem solving were given.

Through the Learning Management System (LMS), students studied online contents independently to complete formative assessments and inquiry-based tasks. LMS provided important notices, contents, assessments, a message board, and supplementary activities. Students also used the LMS to ask additional questions as well as to submit assignments.

These online classes were aimed at learners' inquiry learning. For this aim, the learners studied the concepts through self-directed learning, received an inquiry question, and solved the inquiry task. Concept learning focused on understanding the fundamentals of the subjects. Evaluation of concept understanding was done through multiple choice quizzes. Students were given 100 questions which were divided into a 10-question quiz for each of 8 concepts with the remaining 20 problems being given as a learning check at the end of the program. In addition, students were given two inquiry-based tasks. The inquiry task was designed as a problem-based learning form in which students learned related concepts and solved problems by giving them tasks that they could think deeply about themes rather than convey basic science concepts. The types of inquiry tasks were classified into the following types: applying knowledge learned, performing experiments, solving problems, conducting inquiry tasks, or presenting new ideas. Through the inquiry task, students practiced how to apply the knowledge they had learned previously, how to think in higher order, and had experience in exploring the subject through the scientific process and writing the report. For example, 8th grade physics dealt with the definition, properties, and characteristics of sound and of waves as core concepts. An inquiry task was given to analyze sounds around them such as whistling and music made by rubbing the rims of wine glasses. Supplementary activities were given for students to actively participate in online discussion. Students were encouraged and supported in investigating the concepts more deeply. During the inquiry activities, the tutor provided questions to facilitate inquiry activities. Students asked questions to elaborate on or confirm concepts and inquiring advanced ideas.

Grades were given as a sum of the assessment and the assignment scores using a curve. The grades were distributed in the following way: 15% = A, 25% = B, 30% = C, 20% = D, and remaining = F. Certificates were given to students with A, B, and C grades. As for the supplementary activities, extra credit was added to grades since all extra credit assignments were voluntary.

One tutor was assigned to each class to provide answers to questions, grade assignments, give feedback on assignments, encourage online participation, and evaluate final student grades. Tutors gave questions to promote online participation and understanding, and students asked questions regarding concepts, re-illustration of assignments, and confirmation of understanding. An active discussion was the main learning activity in the online-based class. Tutors tried to give continuous and connected question-based guidance in response to learner questions for the further development of ideas and to encourage active interaction.

Participants

Of the 1,227 middle school students who took part in the 2016 Spring semester online learning program, 827 students who received certificates took part in this research. Participants took part in math, physics, chemistry, or biology courses for 12 weeks from March to June, 2016. 557 students (67.4%) of the participants were male, while 270 students (32.6%) were female. There were 327 7th graders (39.5%), 264 8th graders (32.0%), and 236 9th graders (28.5%). Based on the subjects of the classes, there were 296 students in math (35.8%), and 531 students in science (64.2%), with 251 students in physics (30.3%), 196 students in chemistry (23.7%), and 84 students in biology (10.2%) (see Table 1).

Table 1. Background information of participants

		N	Percentage (%)
Gender	Males	557	67.4
	Females	270	32.6
Grade	7th Grade	327	39.5
	8th Grade	264	32.0
	9th Grade	236	28.5
Subject	Mathematics	296	35.8
	Physics	251	30.3
	Chemistry	196	23.7
	Biology	84	10.2
Total		827	100.0

Among the 827 students with certificates, 149 earned *A*s (18.0%), 262 had *B*s (31.7%), and 416 received *C*s (50.3%) (see Table 2).

Table 2. Academic achievement of participants

Grade achieved	N	Percentage (%)
A	149	18.0
B	262	31.7
C	416	50.3
Total	827	100.0

Data collection

The messages uploaded by students to the LMS in the 2016 Spring semester were analyzed for this study. Primary sorting according to the context of questions was conducted, followed by secondary classification into the three categories shown in Table 3.

Level of learner questions was classified as low-level and high-level, according to the standards given by Moon & Cha (2013), Eliis (1991), Wilen (1991), and Woo et al. (1999b). To be more specific, questions demonstrating no clear understanding of the concept were placed in the low-level question category, while questions with comparisons, applications, and disagreement with the concepts were classified as high-level questions.

Academic achievement on the online course was shown as the average value of the scores of the previously mentioned 100 questions (formative assessment score) and the two assignments (inquiry task score). Supplementary activities for the 8 core concepts were averaged and included the extra credit points (see Table 4).

According to the test scores of students, formative assessment scores averaged 5.23 out of 10 (*SD*=2.98), while inquiry task scores averaged 42.90 out of 100 (*SD*=33.82). Extra credit scores averaged 2.79 out of 10 (*SD*=3.62).

Table 3. Level of questioning

	Contents	Example
Low-level questions	Inquiry for clarification of content without proper understanding of the concept	Hello, I am curious about the meaning of “6 points” on the blue circle on the attached file. Thank you.
High-level questions	Inquiry of application, comparison, advanced idea, agreement/disagreement on the content with full understanding of the concept	I’ve heard that histones can prevent genetic pollution of our DNA. If this is true, histones are actually protecting our bodies from outer dangers! Then, in case of diseases such as Avian Influenza, is it because our histones are not properly functioning at that time?
Other questions	Inquiry about typos in the content, exam period, and other details unrelated to the content	I feel regret about starting it late and not being able to submit it within due date. However, I would like to finish it somehow. In the result part, should I design it theoretically or make a prototype and upload the photo of it? It makes me confused.

Table 4. Student evaluation

Evaluation	N	Mean	Standard deviations
Formative assessment score	827	5.23	2.98
Inquiry task score	827	42.90	33.82
Extra credit	827	2.79	6.62

Three graduate students took part in message sorting, and messages were peer-reviewed by the research team. Disagreements about message categorization were thoroughly discussed among the team to arrive at uniform sorting.

Data analysis

This study aims to discover the relationship between the frequency of questioning and question complexity in regards to academic achievement. To that end, low-level and high-level questions based on formative assessment scores, inquiry task scores, extra credit, total scores, and academic achievement were sorted. Further classification according to the levels of questions, no/other questions, low-level questions, high-level questions, and both-level questions was done.

A descriptive statistical analysis was conducted to see the questioning frequency and level of questioning, using the Chi-square test of academic achievement as a dependent variable and the levels of questioning as independent variables. In addition, one-way analysis of variance (ANOVA) was applied to classifications of levels of questions as independent variables and scores as dependent variables in order to determine the level of academic achievement based on the level of questioning. Lastly, an additional one-way ANOVA on classifications of levels of questions as independent variables and learning activity participation as dependent variables was conducted in order to see the relationship between levels of questions and activity. SPSS 22.0 was used for statistical analysis.

Results

Frequency and level of learner questioning

The number of questions based on the level of questioning of 827 students is shown in Table 5. Among 355 questions generated by participants, 136 questions (38.3%) were categorized as low-level questions, while 193 questions (54.4%) were grouped as high-level questions. Other questions such as error detection in content or assignments totaled 26 questions (7.3%).

As can be seen in Table 6, 676 students (81.7%) either had no questions or uploaded other questions. In addition, low-level questions accounted for 51 students (6.2%), high-level questions were attributed to 59 students (7.1%), and both-level questions were asked by 41 students (5.0%).

Table 5. Number of questions by level of questioning

Level of question	N	Percentage (%)
Low-level questions	136	38.3
High-level questions	193	54.4
Other questions	26	7.3
Total	355	100.0

Table 6. Number of students by level of questioning

Level of question	N	Percentage (%)
Low-level questions	51	6.2
High-level questions	59	7.1
Both-level questions	41	5.0
Other questions	26	3.1
No question	650	78.6
Total	827	100.0

Academic achievement and questioning behavior

The level of questions was sorted based on academic achievement to establish the relationship between them, as shown in Table 7. A Chi-square test was conducted to study the relationship between questioning behavior and academic achievement. As a result, Table 8 shows students with lower academic achievement are less likely to ask questions.

A series of Chi-square tests were conducted to see the relationship between the levels of questions and academic achievement. Table 8 shows the statistically significant relationship between low-level questions and academic achievement. Students with lower academic achievement have a higher probability of asking low-level questions.

Likewise, the relationship between high-level questions and higher academic achievement, as shown in Table 8, shows statistically significant results. Students

Table 7. Number of questions by grade achieved

Grade achieved	Level of question	N	Percentage (%)
A	Low-level questions	61	34.5
	High-level questions	107	60.4
	Other questions	9	5.1
	Total	177	100
B	Low-level questions	47	39.2
	High-level questions	59	49.1
	Other questions	14	11.7
	Total	120	100
C	Low-level questions	28	48.3
	High-level questions	27	46.5
	Other questions	3	5.2
	Total	58	100

with higher academic achievement are more likely to ask high-level questions.

In summary, students with low academic achievement showed less likelihood of asking either low-level or high-level questions.

Academic achievement, active class participation, and questioning

A one-way ANOVA was conducted to see the difference among the groups of questioning, groups with no/other questions, low-level questions, high-level questions, and both-level questions were verified, respectively. The results of the one-way ANOVA were statistically significant. In other words, there was a difference between the formative assessment score and the inquiry task score according to the question level.

In the formative assessment scores, the group of students asking both-level questions showed the highest average score of 7.31 points (*SD*=2.63), while the group who asked no/other questions showed the lowest average score of 4.85

Table 8. Grade achieved and learner's question frequency

	Grade	Frequency (%)	Questioning Yes	Questioning No	Total	χ^2/p
Total of question	A	Observed	38.0(25.5)	111.0(74.5)	149.0(100.0)	χ^2=48.794 p<0.001
		Expected	11.8(7.9)	137.2(92.1)	149.0(100.0)	
	B	Observed	35.0(13.4)	227.0(86.6)	262.0(100.0)	
		Expected	20.7(7.9)	241.3(92.1)	262.0(100.0)	
	C	Observed	20.0(4.8)	396.0(95.2)	416.0(100.0)	
		Expected	32.9(7.9)	383.1(92.1)	416.0(100.0)	
	Total	Observed	93.0(11.2)	734.0(88.8)	827.0(100.0)	
		Expected	93.0(11.2)	734.0(88.8)	827.0(100.0)	
Low-level question	A	Observed	38.0(25.5)	111.0(74.5)	149.0(100.0)	χ^2=47.267 p<0.000
		Expected	16.6(11.1)	132.4(88.9)	149.0(100.0)	
	B	Observed	33.0(12.6)	229.0(87.4))	262.0(100.0)	
		Expected	29.1(11.1)	232.9(88.9)	262.0(100.0)	
	C	Observed	21.0(5.0)	395.0(95.0)	416.0(100.0)	
		Expected	46.3(11.1)	369.7(88.9)	416.0(100.0)	
	Total	Observed	92.0(11.1)	735.0(88.9)	827.0(100.0)	
		Expected	92.0(11.1)	735.0(88.9)	827.0(100.0)	
High-level question	A	Observed	41.0(27.5)	108.0(72.5)	149.0(100.0)	χ^2=49.391 p<0.000
		Expected	18.0(12.1)	131.0(87.9)	149.0(100.0)	
	B	Observed	35.0(13.4)	227.0(86.6)	262.0(100.0)	
		Expected	31.7(12.1)	230.3(87.9)	262.0(100.0)	
	C	Observed	24.0(5.8)	392.0(94.2)	416.0(100.0)	
		Expected	50.3(12.1)	365.7(87.9)	416.0(100.0)	
	Total	Observed	100.0(12.1)	727.0(87.9)	827.0(100.0)	
		Expected	100.0(12.1)	727.0(87.9)	827.0(100.0)	

points (*SD*=2.89). In the case of inquiry task scores, similar results to those shown above were seen with both-level questioning showing the highest average (68.12 points, *SD*=29.27), and the no/other questioning class showing the lowest average

(38.12 points, *SD*=32.45). As a result, the students who had high-level of inquiry showed high scores in formative assessment and inquiry task.

Table 9. Scores by question level

Dependent variables	Level of question (Independent variable)	N	M	SD	F p-value	Result of Post hoc Tests
Formative assessment score	Low-level questions(a)	51	6.66	2.59	F (3,823)= 21.336 p<.001	d<a,b,c
	High-level questions(b)	59	6.83	3.07		
	Both-level questions(c)	41	7.31	2.63		
	No/Other questions(d)	676	4.85	2.89		
	Total	827	5.23	2.98		
Inquiry task score	Low-level questions(a)	51	62.27	30.49	F (3,823)= 27.233 p<.001	d<a,b,c
	High-level questions(b)	59	63.34	34.19		
	Both-level questions(c)	41	68.12	29.27		
	No/Other questions(d)	676	38.12	32.45		
	Total	827	42.90	33.82		

According to the Turkey's post hoc test, there was a significant difference between the formative assessment scores and the inquiry task scores for the group of no/other questions, however, the other groups of questions showed no significant differences.

Active class participation

ANOVA was conducted in order to discover the relationship between learner questioning and supplementary activities, as well as low-level and high-level questions in each of the four questioning groups. This was used as an indicator of student active class participation since participation in supplementary activities was not mandatory though students did earn extra credit for completion. Supplementary learning activities aimed to provide additional information regarding the concepts of knowledge for further study. It was estimated that students with higher formative assessment scores would have higher rates of participation in supplementary activities.

As a result, there was a difference based on the groups of questioning in extra credit, as shown in Table 10. The group of both-level questions had the highest average score of 6.38 (*SD*=3.73) while the group of no/other questions showed the lowest average score of 2.27 (*SD*=3.33)

Table 10. Extra credit by question level

Dependent variable	Level of question (independent variable)	N	M	SD	*F* *p*-value	Result of Post hoc Tests
Extra Credit	Low-level questions(a)	51	4.35	3.91	F (2,823)= 30.882 p<.001	d<a<b=c
	High-level questions(b)	59	4.89	4.02		
	Both-level questions(c)	41	6.38	3.73		
	No/Other questions(d)	676	2.27	3.33		
	Total	827	2.79	3.62		

According to the Turkey's post hoc test, there were significant differences in extra credit in both the groups of both-level questions and high-level questions. In addition, the group of low-level questions achieved higher scores than the group of no/other questions. Groups with many questions as well as high-level questions showed higher participation statistically.

Discussions and Conclusion

This research aimed to explore the effects of frequency, quality, and questioning behavior on the academic achievement of middle school students in an online learning environment. As a result, a small number of students took part in questioning, and students with higher academic achievement showed a higher likelihood of generating both low-level and high-level questions. In addition, the activity of questioning was found to correlate with academic achievement, and the student level of questioning was related to class participation.

Based on the results, we can make the following deductions:

Significance of learner questioning in learner-centered education

Based on this study, it was found that the number of learners actively involved in questioning was small. Although the frequency of questioning was low among learners, those who took part in questioning showed higher achievement on their assignments. In other words, students with high academic achievement actively participated in questioning. Furthermore, students with high academic achievement asked high-level questions throughout the semester. It can be inferred that active student engagement in understanding and analyzing content as well as participation in questioning goes beyond the minimum level of participation required to receive a certificate. However, it will be important to think about how to facilitate learner questions to orient learner-centered learning over mandatory rule.

Then, what is the standard of "meaningful active learning" in learner-centered education? Interaction plays a key role in determining the usefulness of active learning. As Oliver (2002) mentioned, learners need teacher feedback to fully engage in inquiry learning. Interaction with teachers encourages deeper learning. In addition, active discussion among learners through opinion exchange leads to successful learning (Lim, 2003).

On the other hand, there was little relation between the level of questioning and level of academic achievement. This is consistent with the suggestions by Bilaoglu, Arnas, & Yasar (2017) that there are no "worthless" questions. Low-level questions can accelerate learner recall and increase learner cognitive activity. Therefore, it is necessary to find a way to promote both low-level questions and high-level questions at the same time (Riley II, 1986).

The core of learner-centered education is to make learners play a leading role in obtaining knowledge. In order to do so, it is crucial to activate learner questioning. It is also crucial to create class strategies and environments that promote cognitive activities and active questioning by learners (Kheel, 2001; Kim & Kim, 2016). The conventional unidirectional-knowledge-delivering lecture fails to fulfill these needs and that is why a more modern application of appropriate strategies and environments is needed.

Significance of learner questioning in an online learning environment

According to the results of this study, learner questions are related to academic achievement in online learning. Originally, the online learning environment was considered the ideal environment for self-directed learning. However, online learning environments envision the maximum number of interactions among users, and this leads to learning immersion as well as increased academic achievement (Park & Kim, 2006; Skadberg & Kimmel, 2004). The aforementioned interactions often refer to peer-to-peer interactions (Jo, 2005), which include questions and answers as action and reaction (Fulford & Zhang, 1993). In other words, questioning behavior can be developed through active interactions among peers in online learning environments.

Several studies, in discussing learner cognitive engagement in online learning environments (Schrum & Hong, 2002), have mentioned that learners need to be actively involved in activities other than merely logging-in to the environment. One good example of cognitive engagement is questioning. When learners try to understand a concept, analyze data, and prove a hypothesis, learners inevitably participate in cognitive engagement and questioning occurs.

However, some argue that there are limits to eliciting cognitive engagement in meaningful learning activities and propose the concept of blended learning. One notable example is flipped learning. Flipped learning seeks to increase interaction among learners (Bang & Lee, 2015). However, flipped learning is mainly applied in face-to-face learning environments and fails to offer solutions for online learning environments, which is why pre-class learning is referred to as an "online lecture", while hands-on projects in the classroom are referred to as "activities."

Currently, online learning environments are becoming more common. A focus on the process of problem solving rather than on submitting assignments on time is necessary for deeper understanding as well as learning (Oliver, 2002). In other words, rather than creating a learning environment with simple actions and reactions, it is important to provide a dynamic environment in which learners can be engaged (Choi, 2002; Steipen, Senn, & Steipen, 2008).

Conclusion

This study attempts to discover the relationship among learner questioning, academic achievement and class participation in a middle-school-level online learning environment. The effect of the frequency and level of learner questioning on academic achievement has been examined. Based on that relationship between the level of questions and learner participation, it is crucial to continue to create learning environments that prompt active and high-level questioning among learners.

Based on the results, the following conclusions have been reached.

First, research focused on the learner questioning is required. As mentioned earlier, most researchers so far have focused on the effect of teacher questioning in classes. Learner questions were considered incidental. However, it has been shown that learner questioning affects the learner's cognitive engagement and attitude (Joo, 2014); therefore, various aspects of questioning should be considered. Especially, it is important to validate the results of this study through various statistical methods and to draw meaningful implications for the educational field.

Second, research on the level of questioning is needed. Although there is little relation between the level of questions and academic scores, it is believed that there is a close linkage between the level of questions and motivation to learn. This conclusion is based on the effect of questioning on active class participation. Thus, the effects of the level of questioning on learning should be taken into account.

Third, development of various strategies to improve the frequency of and level of learner questioning is necessary. Several studies have produced methods of improving questioning, such as script, template, and worksheet (Ban &, Choi, 2016; Byun, Seo, & Choi, 2016), as well as "question deposition" (Chung & Bae, 2002; Lee, 2016; Moon & Cha, 2013).

Lastly, there is a need for qualitative research that can deeply analyze the relationship between questions and learning. This study used a method of analyzing the content of questions posed by students. As with this study, several studies on the question mainly analyzed statistical results and presented the effect. Accordingly, it is not possible to report in depth how learners asked the question in the learning process based on the level of questions, the content of learning, and the way of learning. Therefore, qualitative research on questions will provide many implications for learning.

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