TÜRK FEN EĞİTİMİ DERGİSİ
Yıl 15, Sayı 1, Mart 2018

Journal of
TURKISH SCIENCE EDUCATION
Volume 15, Issue 1, March 2018

http://www.tused.org

ARGUMENTATION BASED INQUIRY APPLICATIONS: SMALL GROUP DISCUSSIONS OF STUDENTS WITH DIFFERENT LEVELS OF SUCCESS

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Received: 05.08.2016 **Revised:** 08.06.2017 **Accepted:** 07.08.2017

The original language of article is English (v.15, n.1, March 2018, pp25-42, doi: 10.12973/tused.10219a)

ABSTRACT

The aim of this study is to investigate experiences of groups with different success levels during small group discussions in argumentation applications. In the study, case study was based as one of qualitative research patterns. In this line, a success test including mechanical subjects comprising multiple-choice and open-ended questions was applied to students by researches in the beginning of semester. Looking at points taken from the success test, student levels (high, medium and low) were determined and groups were formed in accordance with these levels. Argumentation based inquiry was carried out in "force and effect" subject. Study group consisted of 10 preservice teachers having education in Department of Science Teaching. Voice records of every group were taken during student discussions and analyzed by transcription. Codes prepared by the researches were combined under certain categories and entitled. Results show that students with all success levels were physically and mentally active, the argumentation process was effective and the process contributed to students in terms of reasoning, thinking like a scientist and understanding the scientific process in during small group discussions. Moreover, when student-student questions were examined, there were more questions in high level group than others group.

Keywords: Argumentation, Argumentation based inquiry, Small group discussion.

INTRODUCTION

There is an increasing trend bringing thoughts on how the scientific information is structured and how arguments contribute to the process of scientific information structuring together (Erduran, 2007). It has been accepted by educators that inquiry is very important to reach new information (Ford, 2008). There are many definitions available for inquiry. Inquiry is also mentioned in American National Science Education Standards (NRC, 1996; *p.23*):

> *"Inquiry is a multifaceted activity that involves making observations; posing question; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental*

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evidence; using tools to gather, analyze, and interpret data; proposing answer, explanations, and predictions; and communicating the results."

Benchmarks describes inquiry as a more complex method than doing experiments or explanations and states that the steady advancement of science depends on the enterprise as a whole (AAAS, 1993). In Turkey, the Ministry of National Education revised the Science teaching program and determined raising individuals with science literacy as the main vision of the program. It was set forth in the curriculum that inquiry process should not be considered as only "exploring and experimenting", because it also involves the process of "explaining and forming arguments" (Ministry of National Education (MNE), 2013). Inquiry-based learning is a student-oriented learning approach in which students have a desire to explore everything around them, form powerful arguments regarding the natural and physical world around them, become individuals who are passionate about and value science, in short, obtain knowledge by behaving, living, and thinking like scientists (MNE, 2013).

In the light of definitions regarding inquiry, Erduran (2007) notes that inquiry should not only be handled as a part of the curriculum, but roles of students and teachers in the learning environment should also be defined. In inquiry-based science courses, students deal with the solution of the actual scientific problem, which involves thinking about research topics (Polman & Pea, 2001). In this way, they gain experience by living the process experienced by scientists. Moreover, learners design their own activities and process information, not only memorize it. In the process, the teacher does not transfers information or manage the student, but assumes the role of a guide (Duschl & Osborne, 2002) who facilitates thinking for the student (Anderson, 2002), allows the student to experience the responsibility and excitement of reaching scientific information, encourages the formation of scientific thinking (MNE, 2013), provides the skill of reasoning and guides the research process with questions (Chen, Hand & Benus, 2014).

It is important to organize classes as educational environments providing opportunities that involve inquiry applications and systems that require thinking (Grandy & Duschl, 2007). The curriculum, the teacher and the environment must be in cooperation to this end. Argumentation allows for a learning environment that structures epistemic aspects of inquiry and guides students in forming and assessing scientific explanations (Sandoval & Reiser, 2004). According to Driver et al. (2000), scientific discussions in science courses have four goals: to improve conceptual understanding of students, to improve research ability of students, to improve scientific epistemology, and help students to recognize science as a social practice. As well as making it possible for epistemology of scientific information to be understood better, argumentation allows for a better conceptual understanding of science as well (Osborne, 2005). Argumentation has a central role in science education especially in terms of developing conceptual understanding, improving inquiry skills of students and improving students' understanding of scientific epistemology, thus it is important to include argumentation in science education (Driver, Newton & Osborne, 2000; Chin & Osborne, 2010).

Toulmin (1958) states that arguments are generally logical inferences based on specific information and describes argumentation as students coming up with claims based on quantitative or qualitative data, evidence or theoretical knowledge and presenting evidence on which the claim is based. According to Driver et al. (2000), argumentation is an activity performed via thinking and writing individually or in groups. Fundamentally, science is defined as social activities based on scientific discussions (Kuhn, 1991). Students who engage in these activities form meaningful scientific concepts and understand how a scientist improve the natural world (Hofstein & Lunetta, 2004). Argumentation is also defined as the process of convincing people of the validity of a certain claim (Toulmin, 1958). It is possible to say

based on various definitions of argumentation that it is usually perceived as a dialogical activity that allows people to discuss their ideas (Chin & Osborne, 2010). In this process, students respond to claims of others, make explanations, ask questions and prove the opposite to rebuttal alternative ideas. When students ask questions regarding things which they desire to know, they come to realize what they do not know or become amazed or surprised about these things. Being asked questions or witnessing their peers being asked questions allow them to structure their own thoughts by playing a "thought-starter" and metacognitive or epistemic role (Chin & Osborne, 2010). Moreover, argumentation can take place in individuals' minds as a part of reflective and rational discourse. In classes where argumentation is used, students focus on using theories, data and evidences to form and rebuttal claims (Simon, Erduran, & Osborne, 2006).

Since the beginning of the 1990s in particular, the role of language and communication (speaking or writing) in classroom and structuring of scientific knowledge has been recognized. For example, "Science as Inquiry Standard" highlights the importance of students' understanding of what and how we know through science (Erduran, 2007). Argumentation Based Science Learning is one of the approaches that describe the nature of the science as inquiry and argument, guide students with activities, serve as a metacognitive support to encourage students to reasoning based on data and involve a writing activity that engage both the student and the teacher (Akkus, Gunel & Hand, 2007). Researchers have developed this approach, originally known as *Science Writing Heuristic (SWH)*, to support writing as a form of thinking in science class (Hand & Keys, 1999). However, recent studies emphasize that argumentation is in the nature of the SWH approach (Hand, 2008; Kabataş Memiş & Seven, 2015). SWH is a writing tool involving thought-support, meaningful discussion and science laboratory activities (Hand, Wallace & Yang, 2004).

The SWH approach help students develop a deeper understanding about big ideas related to science content with stages of student template/plan that involve asking and analyzing questions, comparing ideas with others and reviewing how ideas change throughout the process (Akkus, Gunel & Hand, 2007). The SWH approach involves cognition and metacognition approaches for science learning and allow students to blend processes such as making connections between data, method, evidence and claim and formulating and supporting claims in their writing (Hohenshell, 2008). Since the SWH approach involves standard forms such as establishing relations between claims and evidences, it allows students to improve their conceptual understanding (Akkuş, Günel & Hand, 2007). The template aimed at teachers represents the pedagogical dimension of the approach, whereas the template aimed at students represent the learning dimension (Günel, Omar & Hand, 2003). The student template and the teacher template can be seen in Table 1. (Hand, Wallace & Yang, 2004) .

Table 1. The two templates for the SWH: the teacher template and the student template

The science writing Heuristic, Part I: A template for teacher –designed activities to promote laboratory understanding	The science writing Heuristic, Part II: A template for students
1. Exploration of pre-instructional understanding (e.g. individual or group concept mapping).	1. Beginning Ideas – What are my questions?
2. Pre-instructional activities (e.g. informal writing, making observations, brainstorming, and posing questions).	2. Tests – What did I do?
3. Participation in science activity.	3. Observations – What did I see?
4. Negotiation phase I – writing personal meanings for science activity (e.g. writing journals).	4. Claims – What can I claim?

5. Negotiation phase II – sharing and comparing data interpretations in small groups (e.g. making a group chart).	5. Evidence – How do I know? Why am I making these claims?
6. Negotiation phase III – comparing science ideas to textbooks or other printed resources (e.g. writing group notes in response to focus questions).	6. Reading – How do my ideas compare with others?
7. Negotiation phase IV – individual reflection and writing (e.g. creating a presentation such as a poster or report for a larger audience).	7. Reflection – How have my ideas changed?
8. Exploration of post-instructional understanding through concept mapping.	

In the literature, there are both national and international studies performed using the ABI approach and different topics. In these studies, topics such as academic achievement of prospective teachers (Erkol, Kışoğlu & Büyükkasap, 2010; Günel *et al.*, 2010; Hand *et al*, 2004), success of students (Hand & Keys, 1999; Hand et al., 2004; Keys, Hand, Prain & Collins, 1999; Kıngır, Geban & Günel, 2011), student-student/ teacher-student questions (Chin & Osborne, 2010; Günel, Kırgın & Geban, 2012), success levels Akkuş, Günel & Hand, 2007; Grimberg & Hand, 2009; Kıngır, 2011; Kıngır, Geban & Günel, 2012), pre-service teacher education (Aydın & Kaptan, 2014) are handled. Günel *et al*. (2010) investigated the effect of the ABI approach on success of university students in general physics laboratory course and showed that the ABI group was more successful compared to the other group in terms of post-test scores related to mechanics subjects. Similarly, it was seen in a study conducted by Hand, Wallace and Yang (2004) that students who used the SWH approach were more successful in science subjects compared to those who did not. It is important to ask quality questions at every stage (beginning, continuation and conclusion) or this discussion process. Chin and Osborne (2010), who aimed to investigate the qualities of student questions which support argumentation, stated that there were different interactions between groups and concluded that questions were essential and important for discussion. Günel, Kıngır and Geban (2012) highlighted that question strategies and implementation level of the teacher was effective on formation and continuation of the discussion process. Among studies on success levels; in the study conducted by Akkuş, Günel and Hand (2007) with 7 teachers instructing in different grades and 592 students, the SWH applications were examined according to implementation levels of teachers and success levels of students. As a result, it was found that SWH applications were effective on success levels of students. It was stated that the approach allowed students to think within the framework of explaining and interpreting science concepts. Another study was conducted by Kıngır, Geban and Günel (2012) on effects of the SWH approach on performance of students with different success levels. Findings obtained as a result of the study showed that experimental group (in which the SWH approach was used) students had significantly better test performance/success compared to control group (in which the traditional approach was used) students. Also, it was found that students with different success levels had different post-test success levels. Students with low and moderate success levels had better post-test scores compared to the group in which the traditional approach was used.

Previous studies usually emphasized that the ABI approach was more effective compared to the traditional method, contributed to improvement of conceptual understanding of students with various success levels and it was important to ask questions in the process. However, we were not able to find a study on state of and change experienced by students with different success levels during small group discussions in argumentation applications.

Therefore, the aim of this study is to investigate experiences of groups with different success levels during small group discussions in argumentation applications.

The research question determined for this aim is "How are the groups' experiences in different success levels during small group discussions in argumentation applications?"

METHODS

The study utilizes the multiple case study design, which is one of the case study patterns (Yıldırım & Şimşek, 1999). Case study is described by researchers (Yıldırım & Şimşek, 2008; Yin, 1984) as an in-depth research method used in situations allowing for investigation of a recent phenomenon in its natural environment. Therefore, this study evaluates students in three different success levels as higher, middle and lower success groups and examines each group (higher, middle and lower) as a unit of analysis.

Participants

The study group consists of 10 prospective teachers selected from 25 prospective teachers attending Science Education program of a medium-scale university located in Northwestern Turkey in fall semester of 2013-2014 academic year. In this context, a success test containing 28 multiple-choice and 7 conceptual questions on mechanics subjects was applied to the students by the researchers in order to determine their success levels. Test questions were selected from different sources (Çolakoğlu, 2002; Hewitt, 2002) appropriate to students' levels and exams of Student Selection and Placement Center.

Opinions of two faculty members, an expert on physics and an expert on language, were received and necessary corrections were made to ensure validity. At the end of the application, the Cronbach's Alpha reliability coefficient of the test was found to be .71. An answer-key was created for conceptual questions and answers given by students to conceptual questions were scored by an independent researcher, an expert in physics. The student names were hidden. The distribution of questions in the success test according to cognitive stages can be seen in the table of specifications (Table 2). Success levels of students were determined based on their test scores. When determining success levels, the study conducted by Akkuş, Günel and Hand was used as a reference. Average scores obtained from the test and standard deviations were taken into account for success levels. Accordingly, a score a quarter standard deviation around the mean ($\overline{X} - {}^{1}/_{4}\ SD$, $\overline{X} + {}^{1}/_{4}\ SD$) was chosen as a medium achievement level (GM), a score a quarter-standard deviation below the mean ($\overline{X} - {}^{1}/_{4}\ SD$ and below) was chosen as a low achievement level (GL), and similarly a score a quarter-standard deviation above the mean ($\overline{X} + {}^{1}/_{4}\ SD$ and above) was chosen as a high achievement level (GH). There are 7 groups within the scope of the study: 3 groups with 3 students and 4 groups with 4 students. 3 of these groups are in the GL category, 2 groups are in the GM category and 2 groups are in the GH category. One group from each success level was examined within the scope of the study. The GL group contains three students (2 male, 1 female) (coding: $Student_1$ (S_1), $Student_2$ (S_2) and $Student_3$ (S_3)), the GM group contains four students (3 female, 1 male) (coding: $Student_4$ (S_4), $Student_5$ (S_5), $Student_6$ (S6) and $Student_7$ (S_7)) and the GH group contains three students (3 female) (coding: $Student_8$ (S_8), $Student_9$ (S_9) and $Student_{10}$ (S_{10}).

Table 2. *Success Test*

Subject	Cognitive stage					
	Knowledge	**Comprehension**	**Application**	**Analysis**	**Synthesis**	**Evaluation**
Ascending force/density		8,11,12,15,18, C3, C4	9,13,14,16, 17	10, C5		
Force and effect		4, 11, C1	1,2,3,5,6,7	10		
Movement		19,20, 21, 22				
Two-dimensional Movement	25	24	23	C6,C7		C2
Energy and energy conservation		26	27, 28, 29			

Note: Multiple choose questions shows as numeric (1,2,3,…), conceptual questions shows as C1, C2,…

Application

For the purpose of the study, the "force and its effects" subject was used. Students learned the selected subject in the Science and Technology Education Laboratory Applications I course, in which the ABI process was applied. Students performed laboratory activities by experiencing argumentation based inquiry process for a semester. Prior to this process, students were encouraged to engage in discussions based on a text containing complex data and evidence in order to allow them to better understand the argumentation process and establish the relation between claim and evidence. The aim was to allow students gain awareness regarding concepts of question, claim and evidence, which constitute the foundation of argumentation. Then, students treated the mechanics subject throughout the semester in line with the argumentation process. The research encouraged students to engage in discussion about a problem related to the subject of the week (subjects were interrelated). Students wrote two questions which they wanted to answer on the board at the beginning of each session as a group. Then, the researchers and students discussed about the quality of questions and what sort of path to follow to answer these questions. Then, the students performed experiments in groups in order to answer these questions, made claims based on obtained data and observations and supported their claims with evidence. Students performed these activities in small group discussions. A voice recorder was used in each group during applications to record discussions between students during the process. In the meantime, the researchers assumed the role of a guide who encourages students to think, make comparisons and control the process. Then, the groups engaged in a larger group discussion in which they shared their findings with the whole class. In this process, each group presented questions which they tried to answer, what path they followed, their observations and data obtained to other groups together with their claims and evidences. In the meantime, other students asked questions related to claims and evidences of the presenting group. When necessary, the researcher asked questions such as "Do you agree with this idea? Why?" in order to allow students to engage in discussion. After presentations of all group were completed, the teacher provided a general summary and gave the problem of the next week. Within the scope of this application, small group discussions on the "force and its effect" subject were assessed. Questions prepared by each group related to the "force and its effect" subject, the process experienced, experimental results and claims are given in Table 3.

Table 3. *The argumentation process of the students*

	Question	Claim	Evidence
GL	Let us assume we have two books with similar thicknesses and sizes. The books have almost the same number of pages, at least 100. How can we find the maximum static force using these two books only?	The force of friction between 2 pages is smaller than the force of friction between 100 pages.	Single pages moved more easily and quickly, whereas interwoven pages did not move at all.
GM	An object is moved on wooden, glass and carpet surfaces. On which surface does this object have a larger force of friction?	The force of friction is the smallest on the glass surface. Because the glass surface is smoother according to our experiments.	In our experiments, the force applied by the object pulled by dynamometer to pull back the dynamometer was the smallest on the glass surface, thus we can say that the force of friction is the smallest on the glass surface.
GH	Explain the effects of two objects with different structures (eraser and a 100g weight) on different surfaces (glass and table).	Effects of two different objects on the same surface or different surfaces will be different. The same force can create different reactions.	A reaction occurs against the effect. However, since surfaces have different structures, they have different reactions. When the same force is applied to different surfaces, different reactions can be obtained due to structural differences between surfaces (hardness, resistance, etc.). Based on their resistance values, the reaction may be frictions on a surface, whereas the other surface may remain undamaged.

Coding and Analyses

Voice recording was used in small group discussions throughout the process and the recordings were transcribed to obtain written documents. Each document was coded separately by three researchers. Then, the researchers came together and assessed codings. During this assessment, the researchers discussed statements which were coded differently by researchers and reached a consensus. Themes were created once the coding process was completed. Since statements of measurement, prediction, classification, conclusion, interpretation, determination of variables, controlling variables, observation, data presentation, giving references, reference to authority, comparison, planning (experiment arrangement), use of foreknowledge, explanation (communication) are indicators of process skills of the students, these codings were placed under the scientific process skills theme. Since processes such as awareness, monitoring and assessment, which are structured metacognitively, involve metacognitive knowledge and activities (Yürük, 2005), codes of indecision, gaining awareness, decision-making and assessment were placed under the metacognition theme. The supporting argumentation process theme was formed by bringing together codes such as argument, evidence, disprove, justification, inquiry, convincing, acceptance-resistance, and cause-effect. The managing the process theme contains statements related to instruction, peer teaching, making suggestions, proposing alternatives, confirmation, asking for confirmation, controlling the understanding and peer support, which are used by individuals to regulate the usual progress of the process. Apart from these four themes, questions asked by the students during the process were also coded separately as low-level questions (Yes or No questions) and high-level questions (questions that require higher-level inquiry). Codes and themes created are handled in the findings section.

FINDINGS

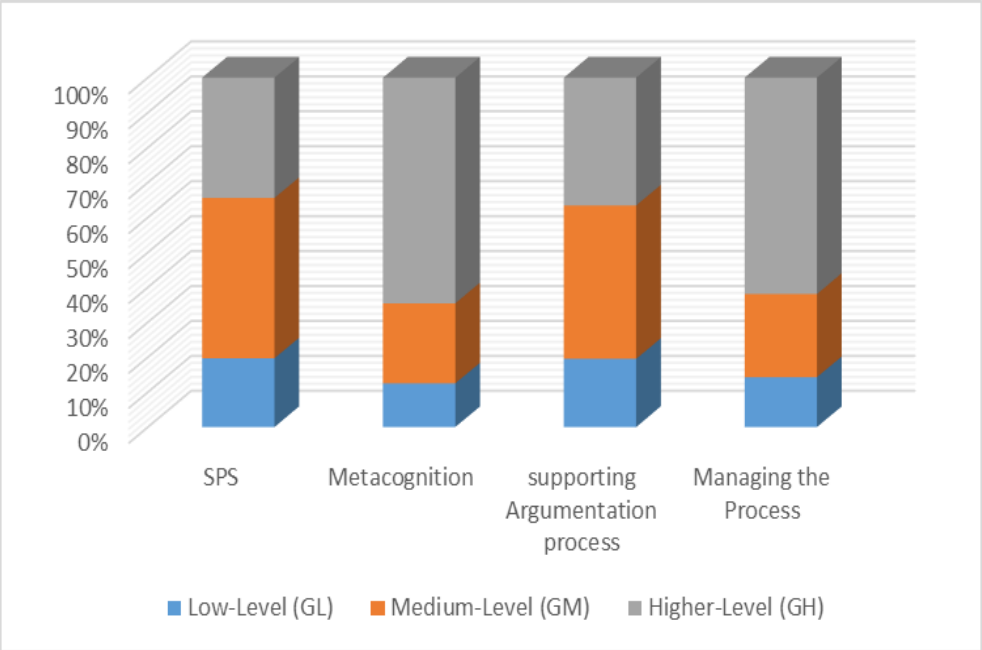
This section contains findings related to the data collected during the research. Themes created following codings determined with analyses and frequencies related to number of codes of each group for each theme can be seen in Table 4.

As seen in Table 4, themes were determined taking into account the processes experienced by the students in small groups (questioning, justification, explaining, explaining, convincing, cause-and-effect relationship, peer teaching, controlling understanding, conspicuousness, decision/indecision, making suggestions, prediction, inference, measurement, etc.). Percentages representing the total number of codes related to first four themes of GH, GM and GL groups can be seen in Graph 1. Findings related to each theme were given with dialogs between students.

Table 4. *Themes and Codings*

Theme	**Coding**	**Groups**		
		GH (f)	**GM (f)**	**GL (f)**
Scientific Process Skills (SPS)	Measurement		2	
	Prediction	2		2
	Inferring	1		
	Interpretation	12		1
	Conclusion	2	7	2
	Controlling variables	1	2	5
	Determination of variables	1		
	Observation		1	
	Data presentation	1	1	
	Giving References	1	2	1
	Reference to authority	11		1
	Comparison	1	2	
	Planning (experiment arrangement)		3	
	Use of foreknowledge	6	4	2
	Explaining	18	4	
Metacognition	Indecision	4		
	Gaining awareness	7	2	1
	Decision-making		1	
	assessment	20	6	
Supporting Agumentation Process	Claim		1	
	Rebuttal	6	2	1
	Justification	10	4	1
	Inquiry	8	6	6
	Convincing		1	
	Resisting	1	1	
	Cause-effect		3	
Managing the Process	Instruction	11	5	1
	Peer teaching	8	5	1
	Making suggestions /	2	7	2

	Proposing alternatives			
	Confirmation	20	12	
	Asking for confirmation	34	5	2
	Controlling the understanding	5	1	
	Peer support	4	1	
Students- students questions	Low-level question	43	28	22
	High-level question	4	1	7



Graph 1. Results of three different groups related to first four themes

As seen in Chart 1, in terms of the scientific process skills theme, the students in the GH group experienced situations reflecting scientific process skills more frequently compared to the students in the GL group, whereas the students in the GM group experienced situations reflecting scientific process skills more frequently compared to both the GL group and the GH group (45.9%). It was found that the students in the GH group used statements such as *"What did the teacher say? There is the force of friction and also the influence of the gravity."* which makes a reference to the authority or statements such as *"Girls, what if we put the weight instead of F and say minus 560 multiplied by k, would that give a net force of 120?"* which represents reasoning, whereas the students in the GL used statements such as *"The force of friction is present if there is contact, if there is no contact, the force of friction is zero."* which reflects making inferences. The Episode 1 shows a sample dialog from small group discussions of the GM group, in which this situation took place most frequently. During the activity where the students in the GM group examined the force of friction by moving an object on different surfaces (wooden, glass, carpet), it was seen that the students used statements such as *"No, we are trying to measure the force of friction on different surfaces, on wood, glass and carpet."* which indicate controlling variables or statements such as *"Let us do it using the other side."* or *"We found it to be 2.6 when we moved the object on the carpet and 1 Newton when we moved the object on the wooden surface."* which reflect inferring.

Episode 1(GM)

S_4 *: The carpet will not slip.*
S_5 *: About 2,5.*
S_4 *: Three, four …*
S_6 *: Do I need to find it?*
S4 ***: Let us use the other side (controlling variables)***
S_5 *: Two.*
S_4 *: Two. Okay, that is better.*
S_7 *: You did not pull it quickly. Here, you pulled it quickly.*
S_6 *: Let us put it equally. It says...*
S_4 *: No.*
S_6 *: But their distances are not the same.*
S_6 ***: Aren't we supposed to pull each of them at the same distance? For example, aren't these supposed to have the same size? (controlling variables)***
(The teacher approaches the table...)
S_7 *: What do you use to find the force of friction?*
S_4 *:* ***No, we are trying to measure the force of friction on different surfaces, on wood, glass and carpet. (explaining)***
(Experiment phase is over...)
S_4 *:* ***We move on the surface of the carpet and found 2.6. (inferring)***
S_6 *: Yes, Newton.*
S_4 *: Yes, Newton,* ***we move on the wooden surface and found 1 Newton. (inferring)***

During small group discussions related to the metacognition theme, the students in the GM group experienced situations reflecting indecision, gaining awareness, decision-making and assessment more frequently compared to the students in the GL group, whereas the students in the GH experienced these situations reflecting these metacognitive processes more frequently compared to both the GL group and the GM group (See Graph 1). Statements such as *"It means that it changes..."* which indicate awareness or *"You did not pull it quickly, but here you did."* which indicate peer assessment were seen more frequently in the GM group. The GH group tried to figure out how to find the maximum static force using two books with similar thicknesses and sizes. A dialog showing statements related to the metacognition theme used during small group discussions of the GH group can be seen in Episode 2. As seen in Excerpt 2, the students in the GH group used metacognitive statements such as *"...We cannot do anything else about it.", "I do not remember this net force", "There is a formula as far as I know but when you include this and that..."* which indicate assessment. These assessment statements were sometimes general assessments, yet it was note-worthy that the students also used self-assessment and peer assessment. Also, as seen in Excerpt 2, the students in this group used statements such as *"But I think it does not cover the action of force. What was Fs? I guess it was not like this. What should I do?"* indicating indecision, which was experienced more frequently compared to other groups.

Episode 2 (GH)

S_8 ***: f to this direction, fs to this direction and mg downwards. We cannot do anything else about it. (assessment)***
S_9 ***: I do not remember this net force. (self-assessment)***

S_{10} *: I mean, we need a primary school text book.* ***But I think it does not cover the action of force. I does cover pressure. Maybe you should check it out. What was Fs? I guess it was not like this. (indecision)***

S_8 ***: There is a formula as far as I know but when you include this and that... (assessment)***

S_{10} ***: Here, I think... How do I do that... (indecision)***

Look, since these forces balance each other, we do not need this.

The argumentation process reflects the discussions between students within the framework of question-claim-evidence triangle. During each stage of the small group discussion, students experience situations such as inquiry, cause-effect, resisting, being convinced, using reasoned statements and rebuttal (their own ideas and peer' ideas). Students form their claims and evidences by finding answers to their questions as a result of these inquiries. Considering the findings related to the supporting the argumentation process (Graph 1), it was seen that the GH group and the GM group used statements supporting the argumentation process more frequently compared to the GL group. The GM group used such statements most frequently. It was found that the students in the GH group used statements such as *"No, it wouldn't decrease."* which indicate confuting, whereas the students in the GL group used similar statements indicating rebuttal such as *"Let's assume it is 1, as 1x5, but it won't work like this, it has a friction coefficient."* or statements indicating inquiry such as *"Now, when we apply forces affecting this, g is downwards, N is upwards, if we assume it does not move, 0.4 does not move as well. Are we supposed to assume it is lower than the threshold value?"*. A dialog showing statements related to the supporting the argumentation process theme used during small group discussions of the GM group can be seen in Episode 3. It was seen in this discussion Episode that the GM students used statements such as *"The rougher the surface is, the higher the friction is."* indicating claims and *"I mean without applying force."* which reflect justification. The group students were also observed to use statements showing the use of cause-effect such as *"If the direction of the force changes, the response changes as well."* or *"Since the weights are the same, there is nothing wrong with comparing them, it is the same thing."*. This group can be said to have frequently experienced situations supporting the argumentation process.

Episode 3 (GM)

S_4 *: Everybody, think.*

S_7 *: Okay, I did. The object keeps moving once you pull it. I would keep moving forever.*

S_4 *:* ***The rougher the surface is, the higher the friction is. (claim)***

S_5 *: Okay.*

(The teacher approaches the table...)

Teacher *: I drew it like this, so there is only G downwards. What do we have upwards? There is N and Fy. The sum of two equals this. Now, when I look at this, the value of the force Fy is downwards this time, right? Look, the force is applied as this.*

S_6 *: Yes.*

Teacher *: Downwards, right?*

S_4 *: Yes.*

S_6 *: Yes.*

Teacher : Since it's downwards, the sum of downwards is equal to the sum of those upwards, right?
S_6 : Yes.
Teacher : In this case, N= Fy+G. Right?

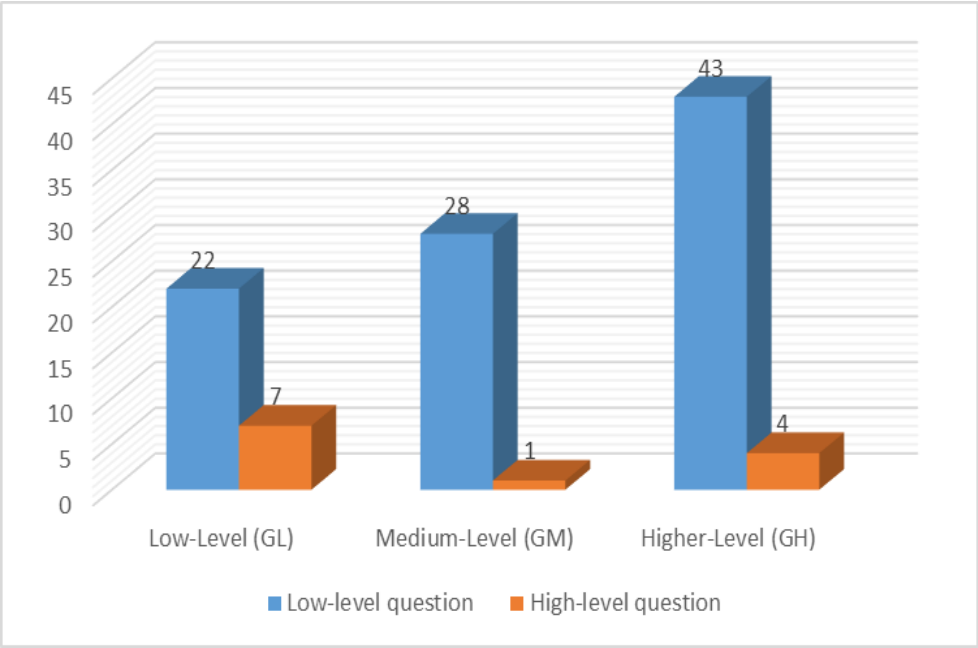
S_6 : Yes.
Teacher : Then what is Fs? k.N. What do we mean by N here? Doesn't N change in this case?
S_4 : It means that it changes, Professor.
S_7 : Teacher, I meant without applying force. (justification)

The managing the process theme contains codes such as instruction, peer teaching, making suggestions, proposing alternatives, confirmation, asking for confirmation, controlling the understanding and peer support. The GM students used statements reflecting this theme more frequently compared to the GL group, whereas the GH group used such statements more frequently than other groups (see Graph 1). Especially during the experiment set-up stage of small group discussions, statements reflecting instruction were used quite frequently. For example, the students in the GM group were observed to use statements such as *"Look at the one right next to 1"* or *"You read the value and I will write it",* which reflect instruction, when performing a measurement with dynamometer.

Students become responsible for each other's learning in small groups. Students often used statements asking for confirmation such as "isn't it?", "right?" or "okay?" during their inquiries. The statements of *"For example, aren't these supposed to have the same size?"* or *"N=mg is the weight, okay?"* can be given as an example for the GM group. A sample dialog between the students in the GH group related to the managing the process theme can be seen in Episode 4. It is seen from the dialog that the students in the GH group frequently used statements related to the managing the process theme such as instruction and asking for confirmation.

Episode 4 (GH)
S_{10} : Girls, we need to find K. We already found mg.
S_9 : What is mg? Multiplied by K and now it is 560.
*S_{10} : **If we assume it is divided by 1, the result is negative for Fnet, right?** The coefficient of friction is usually given zero, how do we find it? (asking for confirmation)*
*S_9 : Girls, now we found its weight to be 560. **This is a separate value, isn't it? (asking for confirmation)***
(When discussing different variables...)
S_8 : S_9, throw both of these wedges. (instruction)
S_9 : This is a bit heavy. Can we move it? Would it form an inclined plane? (asking for confirmation)
S_{10} : Yes, it would. (confirmation)
S_9 : We can do it side-by-side like this. (proposing an idea)
S_{10} : Okay, now it is better.

The total number of questions related to the level of student-student questions theme in the GH, GM and GL groups is given in Graph 2 below.



Graph 2. Results of the groups related to the level of student-student questions theme

It can be suggested that questions asked by the teacher were formed in order to support students' ideas, ensure thinking responsibility between students, encourage students to speak their mind and help students understand the topic on a deeper level or make associations in small group discussion (Chin, 2006). Questions asked by the teacher constitutes an important dimension of the in-class dialog. Within the scope of this study, however, only questions asked by students were evaluated.

Student questions were coded as higher-level and lower-level questions. It was found that students in each group asked lower-level questions more frequently compared to higher-level questions (see Graph 2). As seen in the graph, the GH was the group that used lower-level questions (e.g.: *"Can't we use it as the formula?", "Are we supposed to find it in mg?", "Now, we found its weight to be 560. Isn't this a separate value?", "What is Fs? Isn't it k multiplied by N?"*) most frequently. Among the groups in the study, higher-level questions were asked by the GL group most frequently. The dialog consisting of questions asked by the students in the GL group to their peers can be seen in Episode 5. It can be seen from the dialog that the students in the GL group questioned the process and asked higher-level questions such as *"What sort of force do we need to apply?"* or *"It is 40 Newtons. No, it is 4 Newtons. How many Newtons is that?"*.

Episode 5 (GL)

S_1 ***: Now, we need to apply a small force to this, right? (lower level question)***

S_2 ***: What do you mean we need to apply a small force? (higher-level question)***

S_1 ***: Now, it does not move it, right? (lower-level question)***

S_1 ***: It is 40 Newtons. No, it is 4 Newtons. How many Newtons is that? (higher-level question)***

S_2 *: Now, it does not move when we apply a small force.*

S_3 *: Okay, I got that part.*

S_1 ***: How many Newtons does it take to move it? (lower-level question)***

S_2 : It moves with 0.6, it does not move with 0.4.
S_1 : Right, 0.4. What is the F? F=0.4 Newtons.
S_1 : Okay, but it needs to stop, S2.
*S_1 : **What is N? (lower-level question)***
*S_2 : **…isn't it the Newton value that we found?***
*S_1 : **Isn't it equal to g? (lower-level question)***

DISCUSSION and CONCLUSION

This study was aimed at investigating the process experienced by students with different success levels during small group discussions in argumentation applications. Among the groups with three different success levels, the GH group was the most active in terms of metacognition and process management, followed by the GM group and the GL group. Since metacognition is described as individuals' thinking about the foundation of their believes related to a concept, about evidences that support or do not support a concept, about the status of their perceptions and evaluating consistencies and generalizations within understandings of others (Hennessey, 1993), it can be said that the GH group experienced these situations more frequently and participated in the learning process more actively. Similarly, it was seen in a study conducted by Hand, Wallace and Yang (2004) that students who used the SWH approach were more successful in science subjects compared to those who did not and students gained awareness related to cognitive and metacognitive processes. For this reason, study results are consistent with the above metioned research. Similarly, in terms of process management, the GH group used statements reflecting instruction, peer teaching, peer support, confirmation, asking for confirmation, making suggestions, proposing alternatives and controlling the understanding, which are essential to form arguments, more frequently compared to other groups. Çinici et. al. (2014) found that students enjoyed working in cooperation with each other in argument formation process, engaging in discussions and receiving peer support and found the use of caricatures in the process to be fun.

In the scientific process skills category, the GM group was more effective compared to other two groups and the GH group was more effective compared to the GL group. Although the importance of scientific process skills and discussions to raise science literate individuals is emphasized in the program (MNE, 2013), it is not necessary for each individual to be science-minded, as noted by Kaya and Kılıç (2008). What is meant to say here is that problem-solving is easier for societies consisting of individuals who understand science-related situations/events in everyday life or be efficient in finding solutions to problems making decisions, presenting evidence and making claims. In the study conducted by Ulu and Bayram (2015) with 7th grade students engaging in an activity named "The Relation Between Voltage and Current" within the scope of the Electricity in Our Lives unit, the authors expected students to determine dependent and independent variables, form hypotheses and design an experiment to test their hypotheses and found that the experimental group had a significantly higher level of conceptual learning compared to the control group. As noted by the researchers and observed in this study, students from all age groups find the opportunity to explore concepts related to the subject and other concepts associated with these concepts when activities are performed as laboratory applications based on ABI. Considering the findings related to the supporting the argumentation process, it was seen that the GH group and the GM group used statements supporting the argumentation process more frequently compared to the GL group. The GM group used such statements most frequently. If we consider the study conducted by Ulu and Bayram (2015) once again, one of the reasons behind the difference between the experimental group and the control group in terms of conceptual learning was found to be activities performed by experimental group students at

the "Claims" and the "Evidences" stage of the student-oriented dimension of the ABI approach. Since the SWH approach involves processes such as turning evidences into claims and establishing relations between evidences and claims, it contributes to the improvement of conceptual learning of students (Akkuş, Günel ve Hand, 2007).

Considering student questions in small group discussions, it was seen that students frequently used lower-level and middle-level questions, whereas they did not use higher-level questions. GH was the group that used low-level questions most frequently. In terms of higher-level questions, the students in the GL group asked higher-level questions most frequently. We believe that the reason behind this result is that one of the students was more active compared to other two students in this group. Questioning is essential for an efficient argumentation (Chin & Osborne, 2010). It is very important for the process that students form questions among themselves and express these questions, make inquiries. However, these questions must be quality questions that require inquiry. Students' asking questions constantly does not mean they learned or will learn better (Aguiar, Mortimer, & Scott, 2010). In addition to student questions, teacher questions were examined in the study conducted by Günel, Kıngır and Geban (2012) and it was found that students were as active as teachers in the classroom. In terms of the relation between discussion and the level of questions asked, it was found that the more high-level questions and follow-up questions asked by the teacher, the more discussions occurred. The role of the teacher in the process may be evaluated by examining teacher questions in other studies as well.

Generally, it was found that students with all success levels were physically and mentally active during small group discussions. It was found in the study conducted by Akkuş et al. (2007) by taking different success levels into account that SWH applications were effective on success levels of students. Researchers (Duschl, 2008; Kaya & Kılıç, 2008; Khun, 2010) who consider discussion to be central for science note that teaching students how to engage in discussions with in-class activities can lead to meaningful learning of science concepts. It was found in our study as well that the argumentation process was effective in all success levels and the process contributed to students in terms of reasoning, thinking like a scientist and understanding the scientific process. Students' thinking about and questioning a problem, designing activities, discussing what they learned through these activities with their peers and reflecting on the results in research-inquiry based approaches allow students to gain properties that a science literate individual should have (Demirbağ, 2011). In the study conducted by Hand et al. (2004), it was found that when inquiry based teaching applications were used together with the SWH approach and higher-level cognitive questions were added to the standard experiment structure, students in the SWH group showed a significantly better performance compared to students in the traditional teaching group. Similar studies in the literature show that the SWH approach has positive effects on conceptual understanding as well (Akkuş, Günel & Hand, 2007; Keys, Hand, Prain & Collins, 1999; Kıngır, Geban & Günel, 2012). In this respect, the results of previous studies seem to support our study.

Future studies may investigate the effect of the age factor by conducting studies not only with university students, but also with primary school and middle school. Therefore, experiences of groups with different success levels during small group discussions in argumentation applications were examined using the force and its effects subject. Similar studies may be conducted with different science subjects and their results may be evaluated. Also, studies in which not only scientific issues, but also socio-scientific issues are addressed may be conducted. Since the field knowledge and pedagogical knowledge of teachers are important in argumentation applications, it is recommended that in-service training programs or collaborative projects with universities are held to improve teachers' knowledge.

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Son erişim tarihi: 06 Şubat 2015

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