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Probability Learning in Computer-Supported Collaborative Argumentation (CSCA) Environment

Bilgisayar Destekli İşbirlikli Tartışma Ortamında Olasılık Öğrenme

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ABSTRACT: The aim of this study is to determine the effect of Computer-Supported Collaborative Argumentation (CSCA) strategy on probability learning. In this context, computer-supported material which was appropriate for seventh-grade level (aged 13-14) was developed for the teaching of probability. The material was applied to 8 seventh grade students who were divided into two groups, each consisting of four students. Data were gathered from audio and video recordings of students' interactions and researchers' observation records. CSCA strategy helped students remedy their misconceptions and construct probability knowledge meaningfully by arguing. It also presented a learning environment in which students felt relaxed and learned through entertainment. In order for such applications to be effective, current class populations should be lessened, and the learning environments should be designed as appropriate for class discussions.

Keywords: Collaborative learning, computer-supported collaborative argumentation (CSCA), interactive learning environments, probability, teaching strategies.

ÖZ: Bu çalışmanın amacı, Bilgisayar Destekli İşbirlikli Tartışma (BDİT) stratejisinin olasılık öğrenmeye etkisini incelemektir. Bu bağlamda, 7. sınıf seviyesine uygun olasılık konusunun öğretimi için bilgisayar destekli bir materyal geliştirilmiştir. Bu materyal herbiri dörderli iki gruba ayrılmış sekiz 7. sınıf öğrencisine uygulanmıştır. Veriler, ses ve video kayıt cihazlarından ve araştırmacıların gözlem notlarından elde edilmiştir. BDİT stratejisi yapılan odaklı tartışmalar sayesinde öğrencilerin kavram yanılgılarını gidermeye ve olasılık bilgisini yapılandırmaya yardımcı olmuştur. Ayrıca bu strateji öğrencilere rahat ve eğlenceli bir öğrenme ortamı sunmuştur. Bu tür uygulamaların etkili olması için sınıf mevcutları azaltılmalı ve öğrenme ortamları sınıfça tartışmaya uygun hale getirilmelidir.

Anahtar sözcükler: İşbirlikli öğrenme, bilgisayar destekli işbirlikli tartışma (BDİT), etkileşimli öğrenme ortamları, olasılık, öğretme stratejileri.

1. INTRODUCTION

Computers which have uses in various fields have also been used in mathematics learning environments (e.g., Demetriadis, Papadopoulos, Stamelos and Fischer, 2008; Gürbüz and Birgin, 2012; Lazakidou and Retalis, 2010; Monteserin, Schiaffino and Amandi, 2010; Pratt, 2000; Zydney, 2010). Computer-Supported Teaching (CST) is a strategy that has been employed lately in teaching processes around the World (Baki, Kösa and Güven, 2011; Gürbüz and Birgin, 2012; Gürbüz, Erdem and Fırat, 2012; Huang, Liu and Shiu, 2008; Lazakidou and Retalis, 2010; Liu, Lin and Kinshuk, 2010; Monteserin et al., 2010; Zydney, 2010). CST can be defined as an interactive teaching strategy which is used in organizing the materials in a computer environment, which easily displays them to students and thus, enhances learning. By this strategy, active learning can be achieved by putting students at the center of teaching and an

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environment which presents students the opportunity of selecting on computer screen, of reasoning, of making a lot of trials, of learning in one's own speed can be provided. This environment can help students make sense of the concepts which cannot be mentally visualized by concreting them. In the literature, it is possible to encounter a great deal of studies mentioning the positive effects of CST on students' learning (Azevedo and Bernard, 1995; Blok, Oostdam, Otter and Overmaat, 2002; Christman, Badgett and Lucking, 1997; Fletcher-Finn and Gravatt, 1995; Gürbüz, 2007; Gürbüz and Birgin, 2012; Liao, 2007).

One of the strategies which makes students active in CST process is collaborative learning. Collaborative learning is an effective strategy in providing meaningful learning (Johnson and Johnson, 1989; Slavin, 1995), in sharing knowledge (Hickey, 1997; Stahl, 2006) and in developing critical thinking (Garrison, Anderson and Archer, 2001; Kreijns, Kirschner and Jochems 2003). This strategy is called as Computer-Supported Collaborative Learning (CSCL). CSCL strategy focuses on how interaction of the members of a group can be developed and how the combination of collaboration and technology can facilitate the sharing and distribution of knowledge (Lipponen, Hakkarainen and Paavola, 2004). Dewiyanti, Brand-Gruwel, Jochems and Broers (2007) and Rowntree (1992) stated that CSCL environments stimulated students to explain their beliefs without the fear of being punished or mocked. Thus, learners' active participation and knowledge sharing inevitably occur as a result of learning within these learning environments (Monteserin et al., 2010; Prinsen, Volman, Terwel and Van den Eeden, 2009).

It is important to create an environment in which students may carry out targeted discussions for the effectiveness of CSCL strategy. The teaching approach in such environments is called as computer-supported collaborative argumentation (CSCA) in the literature. CSCA provides students with opportunities to practise critical thinking through argumentation, using text-based communication tools (Baker, 1999). Therefore, it is thought that the process will be more effective when focused discussions are made with small groups in CSCA environments. Focused discussions lead to the following in learning environments:

- It is possible to communicate directly with the group members (Cho and Jonassen, 2002).
- Unexpected negative situations can be handled immediately.
- Knowledge can be constructed via argumentations (Van Amelsvoort, Andriessen and Kanselaar, 2007),
- The learnings of group members may be tracked more closely (Cobb, Yackel and Wood, 1992).
- Students might identify and remedy other group members' misconceptions via in-group discussions (Yackel, 1991).
- The argumentation process develops pupils' reasoning (Andriessen, Baker and Suthers, 2003; Cerbin, 1988; Kuhn, Shaw and Felton, 1997) and problem-solving skills (Erkens, 1997).
- The teacher finds opportunities to intervene in order to stop pupils' mistakes immediately (Cobb, Yackel and Wood, 1991; Wood, Cobb and Yackel, 1991).
- Pupils develop self-confidence and might engage in discussion with the teachers.
- The discussion environment helps pupils use mathematical language (Yackel, Cobb and Wood, 1999).

- The view of "*the teacher as the sole source of knowledge*" changes to a view of "*I can also learn from myself or from peers*".

In the literature, it is suggested that the teaching of probability and statistics should be performed by presenting the subject in an interesting way (Sanders, 1995), providing ongoing experiences with experimental activities and random generators (Truran, 1994), recognising and confronting common errors in students' probabilistic thinking (Shaughnessy, 1992), creating situations requiring probabilistic reasoning that correspond to students' views of the world, and introducing topics through activities and simulations, not abstractions (Bezzina, 2004; Garfield and Ahlgren, 1988). In this sense, it is thought that one of the effective ways of teaching probability as mentioned above is to employ CSCA strategy in learning environments. The aim of the present study is to determine the effect of CSCA strategy on students' learning of probability.

2. METHOD

2.1. Research design

The present study is a case study. The most important characteristic of case study is that it allows researchers to focus on a special subject, group or situation (Yin, 2011).

2.2. Participants

This study was conducted with 8 seventh-grade students (aged 13-14) studying in a middle school in the southeastern region of Turkey. With the help of their teachers, the students from a 28-student class were selected *(from low to high mathematics ability levels)* and then divided into two groups with four students in each group. These students were given code names such as "Büşra *(low),* Kübra *(middle),* Musa *(high)* and Hasan *(low)* [group A]" and "Hilal *(high),* Merve *(middle),* Tuğçe *(low)* and Ali *(middle)* [group B]". The pairs were formed as low-high, low-middle or middle-high groups. While a more experienced (in terms of professional experience and academic studies conducted on probability subject) researcher (researcher A) carried out the application process of group A, the less experienced one (researcher B) carried it out in group B.

2.3. Data collection

Data were gathered from audio and video recordings of students' interactions, researchers' observation records and evaluations of students' thinkings. One camera was placed near each group in order to prevent data loss during the applications. When the students were involved in an application, we were able to observe their behaviour and their articulated expressions. Triangulation of these sources of data enabled us to develop different perspectives and interpretations of students' reflections.

2.4. Computer-Supported Material (CSM)

CSM used in this study was developed on Java language and NetBeans editor. Many applications regarding a classical die, a die designed in a different form, a classical die and coin, two classical dice, two dice designed in different forms, a spinner, a spinner and coin, a spinner and a die, two spinners, numbered race horses, and race cars were embedded into the interfaces in this material. In the interfaces of the material, the students could receive feedback related to their answers. For example, one question (see Figure 1) was directed as follows: "*In an experiment of rolling two classical dice together, which is more likely, getting the total of 4 or*

10?" If the student gave the answer "equal", then she/he would receive this feedback: "*Congratulations! Correct answer.*" Then, students' meaningful learning was the goal during the researcher's follow-up questions, such as, "Why equal?", "How did you decide this?" Otherwise, students would receive a different kind of feedback for false answers. For example, for the answer "4" or "10", feedback such as "How many outcomes giving the total of "10" or "4" are possible in rolling two classical dice?" was provided. In addition to this feedback, researchers tried to correct their false justifications by asking questions such as, "Why 10 or 4?". Students' false justifications such as, "10 is bigger", "10, because there are more pairs that equal the total of 10; 8+2, 7+3, 9+1, 6+4, 5+5." were corrected by arguing them.

This material also enables students to correct the misunderstandings in their minds because of the existent feature of summarizing the outcomes of all trials made by students. Moreover, to support this process, instructional tasks were presented to students on paper in order that groups discuss effectively by making them go away from the computer screen. For example, an instructional task such as, "Musa and Meryem play with a pair of dice. If the sum of the points is 3, Musa is the winner. If the sum of the points is 6, Meryem is the winner. Who seems more likely to win? Why?" was applied. Students' conceptual learnings were provided by arguing these instructional tasks together with the questions in computer material. This whole process enabled learners to make applications on the computer screen, to work in groups, to communicate effectively and to construct knowledge together and helped them make concrete the abstract mathematical concepts. Also, one of the most important features of this material is that it allows users to make repeated trials randomly.

This material was pilot-studied with 20 seventh-grade students who did not participate in the real study and were divided into five groups, each consisting of four students. By the pilot study, probable deficiencies of the material and the problems which could be encountered during application process were determined and necessary corrections were made. For example, students recognized that the outcomes of trials obtained by them during the pilot study often differed from theoretical probability. This difference caused disequilibrium due to the fact that limited trials could be made in the material. Therefore, material was converted into a form which allowed unlimited trials. Moreover, it was observed that noise pollution from working with 20 students in the same environment resulted in the following: both the students and the researchers experienced mental fatigue, analysis of 5 different students groups became difficult due to the mixing of sounds, and performance of focused argumentation proved impossible. Thus, the real study was decided to be conducted with 2 groups. Two sample interfaces from the designed computer-supported material are illustrated in Figure 1 and Figure 2.

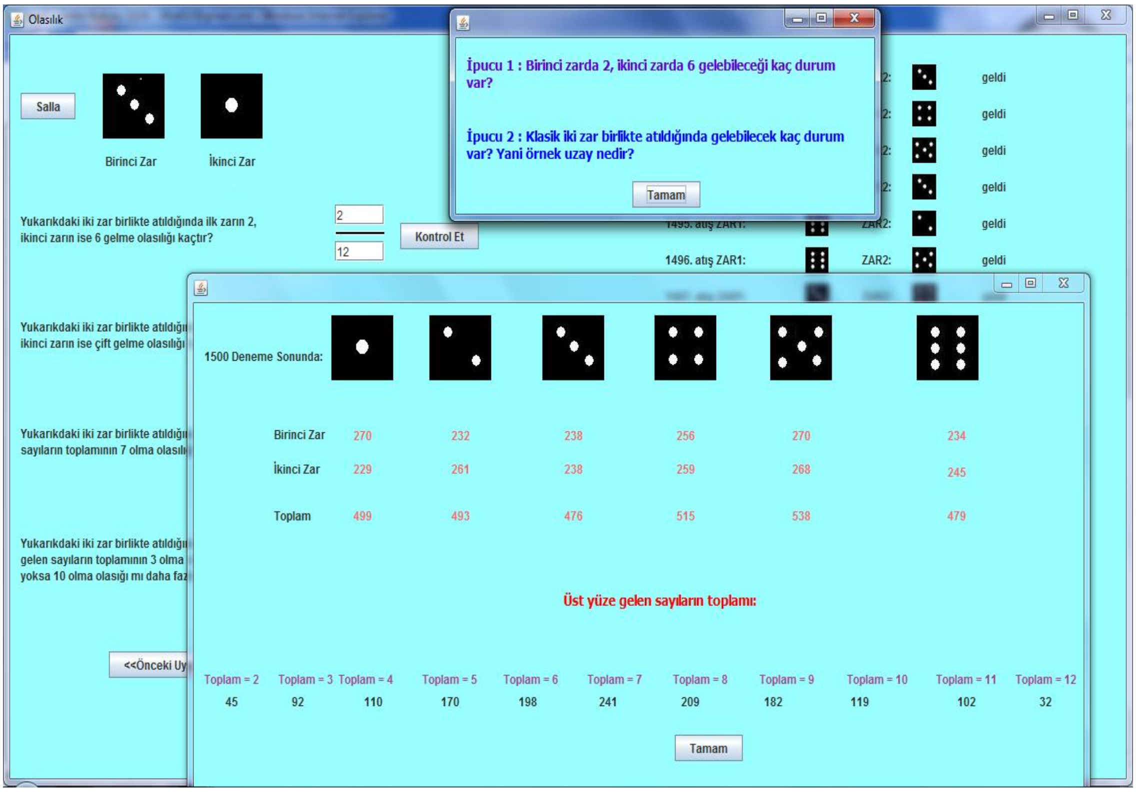

Figure 1. An interface from CSTM

2.5. Procedure

Applications were performed throughout four class hours (each 40 min.) with two groups each consisting of four students. Two different researchers guided groups in this process. The groups were placed far away from each other in order to gather the sounds of each group clearly and therefore all process could be recorded in detail. Researchers tried to create a discussion environment in order to enhance the effect of material and to determine and to remedy the misconceptions by asking questions regarding daily life. Researchers asked questions such as, “Why?”, “How?” for providing meaningful learning and for obtaining students’ justifications during this process. The application process began with questions related to daily life such as, “Which one is more likely, the falling of a celestial body into land, or sea? Why?” After this question had been discussed shortly, an activity of car racing in a computer environment was presented to students. Two cars coloured with red and black race on a race track in this activity. Researchers asked the groups various questions such as, “If you were a pilot in this race, which car would you choose? Why?”, “What do you think about your losing?” After a short group discussion, various questions related to a die such as, “What is the probability of getting a 1?”, “What is the probability of getting a 6?”, “What is the probability of getting even numbers?”, “Which side is it more likely to land on?” were asked and discussed by letting groups perform numerous trials with a classical die on a computer screen. Then, students were asked to re-assess their answers on an interface summarizing the outcomes of all trials and made various inferences together with researchers.

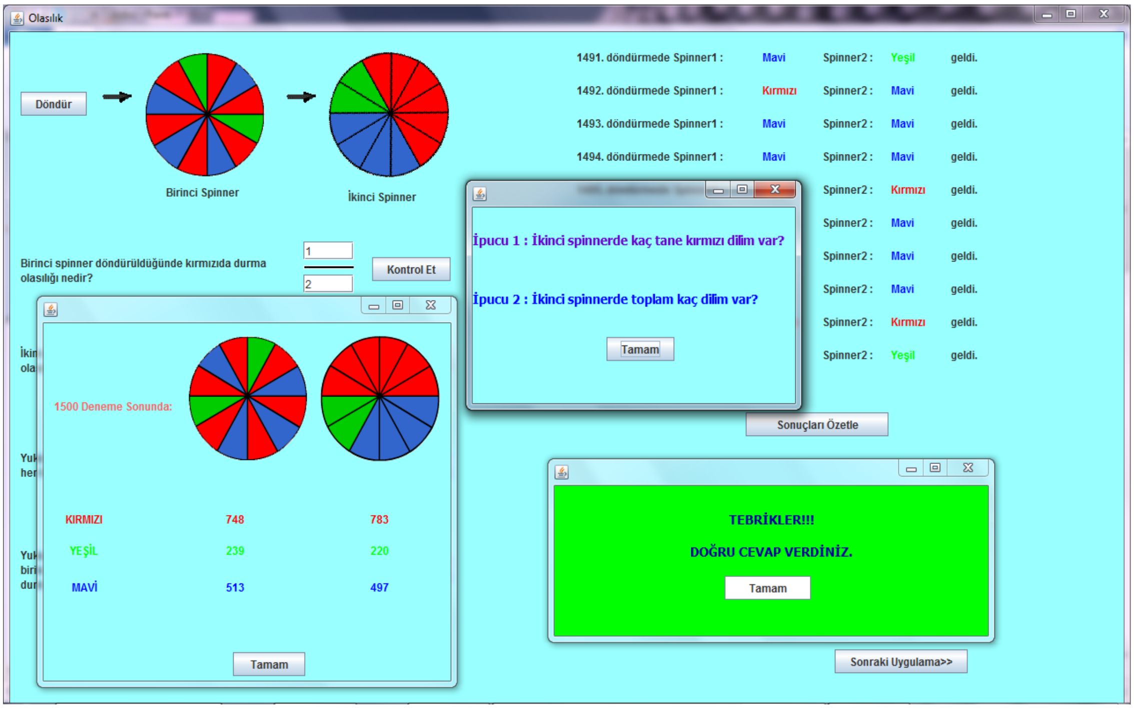

Figure 2. Another interface from CSTM

This process continued with complex experiment applications to attain higher level learnings. For example, the questions such as, "when these spinners are turned at the same time which one is more likely to stop at red colour? Why?", "When these spinners are turned at the same time what is the probability of the first spinner to stop at green and second at blue?" were asked to students by using the spinners in Figure 2. Researchers also applied instructional tasks to groups throughout this process. For example, students' probable mistakes arising from their classical die perceptions were prevented with the application of an instructional task such as, "Ali and Berk are playing a game by using toy cars on a 10-step path. Each player will roll two dice designed such as (333 444) and (222 555) at the same time and look at the sum of the numbers on the upper faces of the dice. If this sum is an even number Ali and if it is an odd number then Berk will move his car a step forward. Whoever reaches the end of the 10-step path first will win the game. In your opinion, who wins the game? Why?". Briefly, meaningful learning was tried to provide by determining whether or not students' inferences from the experiments on the computer screen were appropriate for mathematical knowledge and by instructional tasks and by discussion during all process.

Throughout this process, the researchers, instead of just lecturing, demonstrating, administering tests and evaluating, also acted as organizer, facilitator, counselor, cooperator, and supervisor. For example, it was seen that the students who did not participate in the beginning did so actively in the process with researchers' suitable interventions throughout the whole process. Moreover, researchers' effective feedback within the process helped students both realize their errors and perform effective learning. However, when analyzing data, it was observed that the more experienced researcher (researcher A) conducted the process more efficiently and thus students in this group worked more collaboratively and performed meaningful learning. Briefly, this environment enables students to become more active, to work more collaboratively**,** to correct their own errors, to improve their knowledge, and to explain what they had just learned. A picture monitoring learning environment was presented in Figure 3.

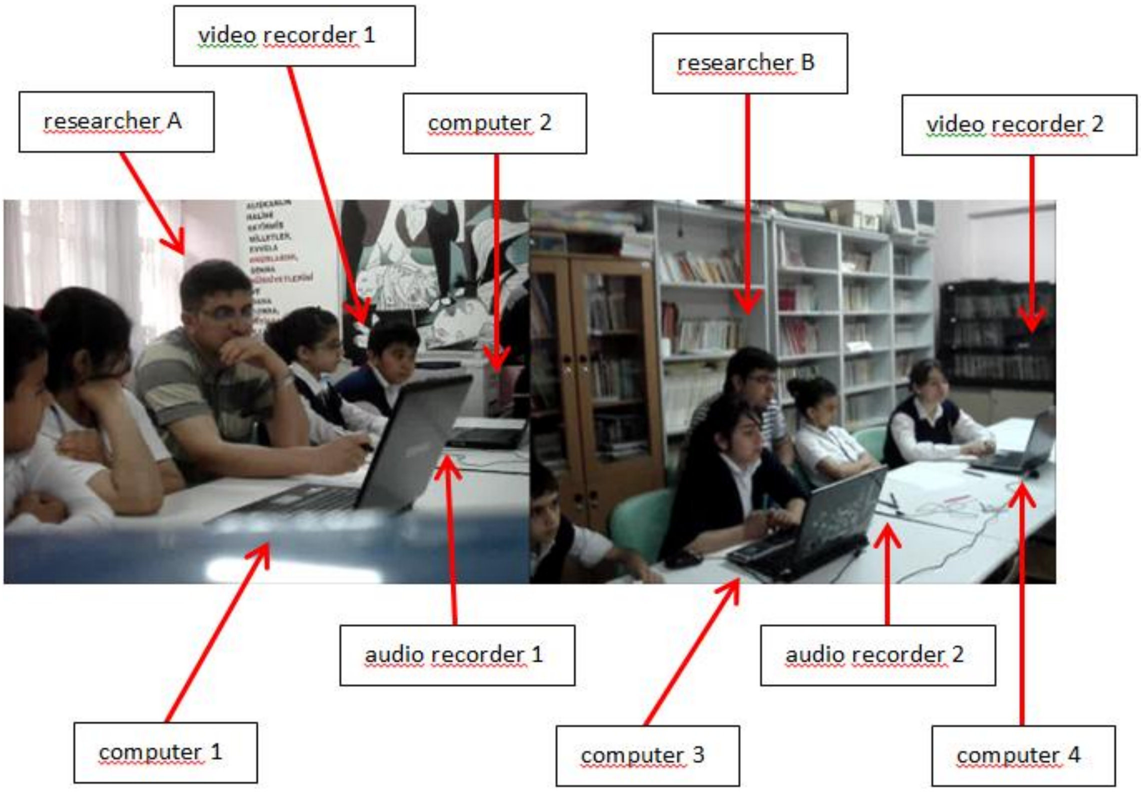

Figure 3. The picture of learning environment

2.6. Data analysis

In such studies focusing on groups, feedback given by researchers depending upon their experiences can affect students' participation in active attendance, performing effective collaboration, evaluating the effectiveness of material and determining and remedying the misconceptions. Therefore, the researchers met regularly to evaluate the ongoing process. They arrived at a consensus on how to take the next steps by watching the video records after first implementations. Via these video records of the proceeding implementations, it was observed that the process progressed more effectively in the less experienced researcher's group in comparison with the previous ones. The multiple evaluations of all the records by the researchers indicated that it is not feasible to transfer all the data to the study. So, one each section summarizing the entire process in each group was directly transferred to findings as Yin (2011) stated. Furthermore, the researchers consulted their observation notes when necessary in the data analysis. In brief, it ensured to present more efficiently what was occurring in the application process.

3. FINDINGS, DISCUSSION AND CONCLUSIONS

In the beginning of the process, it was observed that students, especially those with high mathematics ability, were both worried and curious about how the process would run. Low mathematics ability students were observed rarely to participate and generally to observe their more successful peers in the beginning. It was also observed that these students became surprised when they looked at the performances of their more successful peers on the computer screen. They expressed their astonishment with body language and with some exclamations such as, "Wow!", "That's great" and so on. It could be suggested that the initial surprise and anxiety turned instead into a positive learning attitude as the tasks progressed. As time passed, despite some deficiencies in the beginning, it was monitored that all the students enjoyed working in CSCA environment.

The application process began with the questions related to daily life (an example given in the procedure). For example, a question, "What are the factors that have influence on winning in backgammon? Do you think they have anything to do with chances of winning in backgammon? Why?" After this question had been discussed for a while, a dialogue regarding a question in the material as follows: "Two players are playing a game. The first player tosses a coin and wins a point every time it turns up heads. The second player rolls a six-sided die (123 456) and wins a point every time an even number (2,4 or 6) comes up. If you were one of the two players, would you choose a coin or a die? Please explain," arose in group A:

Büşra: *I would choose a die.*

Kübra: *Why?*

Büşra: *Because, while there are three cases leading to win in die, there is only one chance with a coin.[Silence]* Researcher: *Büşra compares only the number of cases asked [by looking all]*

Musa: *False! Because, we must consider probabilities of those events.*

Büşra: *No… [Silence]. I don't know…*

Musa: *Isn't it right that the probabilities of winning in both events are* $\frac{1}{2}$ *?*

Kübra: *Yes…*

Büşra: *How* $\frac{1}{2}$ *?*

Musa: *There are two cases in coin: either heads or tails.*

All: *Yes [in agreement].*

Musa: *With a coin, there is only one case asked (heads), thus the probability of getting heads is* $\frac{1}{2}$.

Büşra: *But… while with a die there are six possibilities, mmm[thinking]…in a coin…*

Musa: *You are right because there are 6 cases with a die: 1,2,3,4,5,6.*

Hasan: *I think so…*

Musa: *The number of cases asked (even numbers) is 3, so the probability is* $\frac{3}{6} = \frac{1}{2}$

Büşra: *Hmm… You look at only the probabilities of events.*

Büşra made a mistake by comparing the number of even numbers in a die with the number of heads on a coin. Lamon (1999) stated this approach as *part–part schema*. However, in this question, Büşra had to use *part–whole schema*. According to Lamon, whereas *part–part schema* is a conceptual structure that enables the learner to compare or order parts of a whole, *part–whole schema* is a structure that enables the learner to compare parts to a whole. It can be said that the factor that Büşra's knowledge of sample space is not sufficient is effective in this wrong approach. In the literature, many studies (Bezzina, 2004; Chernoff, 2009; Erdem, 2011; Gürbüz, 2010; Keren, 1984; Nilsson, 2007; Polaki, 2002) mentioned the important role of sample space concept in understanding the probability concepts. However, it will be seen that CSCA is effective in Büşra's comprehending the difference between these two schemas late in the process.

Dialogue continues…

Kübra: *Okay. We must compare the probabilities.*

Büşra*: Presumably I understood… The probabilites of both events are equal.*

Researcher: *Hasan, what do you think about it?*

Hasan: *I think so… right… but some luck is also required.*

Researcher: *Can you explain with an example?*

Hasan: *For example, in a game, both my friend and I may win. Whoever's lucky day it is wins. Also, I see the effect of chance factor in my dad and uncle's die game.*

That Hasan, who does not participate in the beginning of process, states that winning the game depends on luck late in the process surprised both friends of his group and the researcher. It can be said that in Hasan's approach, games of chance are played in his family and that these types of chats, which take place among in his kith and kin, are effective. It was understood that Hasan's justifications were affected by his individual learning, experiences, culture, and beliefs. Amir and Williams (1999), Batanero and Serrano (1999) and Sharma (2006) reported the effect of similar factors on probability learning.

Dialogue continues…

Büşra: *Luck? But… No no…*

Kübra: *I think so… In games, luck could work but here, there is no luck…*

Hasan: *Why?*

Kübra: *We must compare probabilities.*

Researcher: *How about making trials by using materials?*

All: *Yes! [with enthusiasm]*

All the students conducted a lot of trials by using materials.

Musa: The *outcomes of the trials confirm what we talked about.*

Researcher: *How? Can you explain that to us?*

Musa: *I made 1000 trials. While in the coin tossing experiment, 461 times it came up heads, 539 times tails came up. In the die rolling experiment, 164 times 1, 157 times 2, 165 times 3, 180 times 4, 170 times 5 and 164 times 6 came up. The number of even numbers (2,4,6) is 501 and of odd numbers (1,3,5) is 499. From these outcomes, we can see that these are approximately equal.*

Researcher: *Hasan, can you make 500 trials, Kübra, you 2000 and Büşra, you 10000 with the coin and die?*

Trials are being done…

Researcher: *Kübra, can you explain the outcomes?*

Kübra: *We must take proportions of outcomes into account, not outcomes.*

Musa made 1,000 trials, P(H)(Probability of getting heads)=461/1000=0.461; P(2,4,6)(Probability of getting 2,4,6)=501/1000=0.501

Hasan made 500 trials, P(H)=232/500=0.464; P(2,4,6)=243/500=0.486

I made 2,000 trials, P(H)=974/2000=0.487; P(2,4,6)=1002/2000=0.501

Büşra made 10,000 trials, P(H)=4988/10000=0.4988; P(2,4,6)=4956/10000=0.4956.

These proportions show that the probabilities of all are almost %50.

Hasan: *Then, we can say that probabilities are equal.*

Büşra: *Why aren't proportions precisely* $\frac{1}{2}$ *and why do they change constantly?*

Researcher: *Very good. Büşra is principally right. You were acting according to theoretical probability before conducting trials with the materials. This subject has been taught in your school books according to theoretical probability. In theoretical probability, it is admitted that when a die is rolled 6 times, each side comes up once. In fact, it may not be like this. When looking at the outcomes of trials, we can say the same things. When a classical die is rolled 6 times, "1" may not come up at all or "1" may come up more than once. But, if we perform 1000 or 10000 trials, the probability of getting 1 will be approximately 1/6. Briefly, when theoretical probability is asked to be confirmed with experimental probability, as many trials as possible must be made.*

As seen in the dialogue above, it can be said that CSCA is an effective strategy in teaching probability. Here, it can be seen that this process helped students remedy their misconceptions. Similarly, the studies of Lee (1988), Chang and Chien (1996), Gürbüz and Birgin (2012), Liu et al. (2010) and Zydney (2010) revealed in their studies that computer supported teaching was effective in remedying misconceptions.

As applications progressed, it was seen that students participated more actively as a result of their self-confidence, learningin a comfortable environment and the fact that they got used to the material. In this sense, Rowntree (1992) and Dewiyanti et al. (2007) pointed out that CSCA environments stimulated students to explain their beliefs without the fear of punishment and being mocked. In the process, it was observed that students also gave true responses individually because of the fact that they easily shared ideas with each other and the researcher guided their discussions effectively. Therefore, students have more meaningful and permanent learning due to the fact that they construct knowledge themselves with the guidance of a researcher.

In this part, a dialogue arising from group B guided by the less experienced researcher (B) was presented. Here, you can see this dialogue related to another question (see Figure 4) below.

When the spinners on the left are turned at the same time which one is more likely to stop at red colour? Why?

Figure 4. Another sample question

Ali: *Spinner B.*

Researcher: *Why spinner B?*

Ali: *As the reds are all together in this spinner, it is more likely to stop at red...*

Merve: *I think it is spinner A.*

Researcher: *Why do you think it will be spinner A?*

Merve: *Because, in spinner A, there are so many reds and they are distributed everywhere, it could stop at red anytime.*

Hilal: *I believe the place of colours does not matter...*

Tuğçe: *But…*

Researcher: *Then, what matters?*

Hilal: *Its number...*

Researcher: *Tuğçe, were you going to say something?*

Tuğçe: *Is the person turning the spinners known?*

Hilal: *I think whoever truns the spinners will not affect the result.*

Tuğçe: *But, some turn them fast while others are slower. I believe this affects the result.*

Merve: *What do you mean?*

Tuğçe: *The person turning the spinners could turn it faster to have it stop at spinner A while s/he can turn it slower to stop it at B.*

Ali: *Sir, when we click on the turn button in a computer environment, spinners are turned. I did not understand this...*

Hilal: *True, spinners are turned in a computer environment. We do not have a chance to interfere with the speed of the spinner on the screen anyway...*

Researcher: *Okay, how about doing the trials together and discussing the results from different perspectives?*

All students screamed*: "All right!"*

Researcher: *Hilal, turn the spinner 100 times, Ali, turn it 500 times, Merve, 1000 times and Tuğçe 5000 times and let us see what you get afterwards.*

Ali: *According to the trials I have made, the results are almost the same, no difference in spinner A or B.*

Hilal: *My results are quite alike...*

Merve: *Mine, too…*

Researcher: *Ali, please, show your results to us.*

Ali: *I spun it 500 times. Spinner A stopped at red 248 times, at blue 177 times and at green 85 times. Spinner B stopped at red 254 times, at blue 162 times and at green 84 times.*

$P_A(R)$ *[The probability of spinner A stopping at red]=248/500;* $P_B(R)=254/500$.

Hilal: *I spun it 100 times. Spinner A stopped at red 52 times, at blue 33 times and at green 15 times. Spinner B stopped at red 49 times, at blue 33 times and at green 18 times.*

$P_A(R)=52/100; P_B(R)=49/100$.

Merve: *I spun it 1,000 times. Spinner A stopped at red 504 times, at blue 330 times and at green 166 times. Spinner B stopped at red 500 times, at blue 330 times and at green 170 times.*

$P_A(R)$=504/1000; $P_B(R)$=500/1000.

…

Researcher: *Tuğçe, what do you want to say after all these trials?*

Tuğçe: *I actually got it. The program turns it itself; we do not have a chance to interfere.*

Researcher: *Then, what do you think about the question?*

Tuğçe: *Looking at the experiments we have carried out as groups, I can see that the number of both spinners stopping at red is almost equal. I think there is no difference between spinner A and B.*

…

After 100, 500, 1000 and 5000 trials with the use of materials, students started a discussion process in which they compared the probability of both events and continued this until all students agreed upon results. As students have gathered the results through their own experiments, they have learnt in a confident manner.

Analyzing students' dialogues, it was observed that, in the beginning of the process, students were thinking one-way and superficially. For instance, that Ali and Merve focused on the place of the red slices on the spinners and that Tuğçe's replies were based on the speed of the spinner show that they could not think according to mathematical thinking. Jones, Langrall, Thornton and Mogill (1997) has actually categorized these thoughts as non-mathematical. It could be noted that these students have misconceptions related to probability. Similar misconceptions can be found in studies by Erdem (2011), Fischbein, Nello and Marino (1991), Gürbüz, Çatlıoğlu, Birgin and Erdem (2010), Gürbüz, Birgin and Çatlıoğlu (2012) and Gürbüz and Birgin (2012) and Jones et al. (1997). Towards the end of the CSCA process, inferences students have made through many experiments and discussions of these inferences with the help of researcher in the group made the process more effective, fun and helped students remedy their misconceptions. It is possible to see similar positive outcomes regarding CSCA in the literature (Baker, 1999; Dewiyanti et al., 2007; Monteserin et al., 2010; Rowntree, 1992; Van Amelsvoort et al., 2007; Veerman 2000).

Briefly,

- CSCA strategy provided a friendly, comfortable and entertaining environment.
- In this environment, students had meaningful learning by making limitless trials on computer screens and arguing with each other about the results of these trials.
- This environment was effective in determining and remedying students' misconceptions.
- It can be argued that the process made a contrubution to students' development of mathematical language and communication skills.

It is thought that the effective guidance and working with few groups are the other factors which enhance the effectiveness of CSCA. In order for these applications to be effective, current class populations must be lessened, and the learning environments must be designed as appropriate for class discussions.

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Uzun Özet

Yaşamın her alanına giren bilgisayarlar öğrenme ortamlarında da kullanılmaktadırlar. Bilgisayarların öğrenme ortamlarında kullanılmaya başlamasıyla birlikte Bilgisayar Destekli Öğretim (BDÖ) kavramı ortaya çıkmıştır. BDÖ, öğrenciye seçme, muhakeme etme, çok sayıda deney yapma, zihninde somutlaştırma ve kendi hızında öğrenme gibi fırsatlar sunmaktadır. BDÖ kavramının öğrenme ortamlarına girmesiyle birlikte eğitimciler öğrenme sürecinde kullanılmakta olan tüm stratejileri bilgisayar teknolojisiyle bütünleştirmeye çalışmışlardır. Bu stratejilerden biri de Bilgisayar Destekli İşbirlikçi Tartışma (BDİT)'dır. BDİT, BDÖ'nın sunduğu fırsatların yanı sıra bir konu ya da kavramı amaçlı bir şekilde küçük gruplar halinde tartışmaktır. Bu ortamlar, öğrencilere kritik düşünme, etkili iletişim kurma ve anlamlı öğrenme fırsatı sağlarken öğretmenlere ise etkin dönüt verme imkanı sunmaktadır (Andriessen, Baker ve Suthers, 2003; Kuhn, Shaw ve Felton, 1997; Cobb, Yackel ve Wood, 1991; Yackel, Cobb ve Wood, 1999). Buradan hareketle bu araştırmanın amacı, BDİT ortamında gerçekleştirilen olasılık öğretiminin öğrenmeye etkisini ortaya koymaktır.

Bu araştırma, Güneydoğu Anadolu Bölgesindeki bir ortaokulda okuyan 13-14 yaşlarındaki 8 öğrenciyle yürütülmüştür. Bu öğrenciler, 28 kişilik bir sınıftan matematik öğretmenlerinin yardımıyla matematik başarıları birbirinden farklı olacak şekilde seçilerek iki gruba ayrılmışlardır. Her bir grup kendi içinde düşük-orta ve orta-yüksek olacak şekilde ayrılarak, uygulamalar grupların birinde deneyimli diğerinde ise daha az deneyimli bir araştırmacı gözetiminde yürütülmüştür. Bu araştırmada kullanılan bilgisayar destekli materyal, Java programlama dili ve NetBeans editörü kullanılarak geliştirilmiştir. Bu materyaldeki ara yüzlere klasik bir zar, farklı formda tasarlanmış bir zar, klasik bir zar ve bir para, klasik iki zar, farklı formda tasarlanmış iki zar, bir spinner ve iki spinneri içeren uygulamalar yerleştirilmiştir. Materyalin her bir ara yüzünde öğrenciler verdikleri cevaplara bağlı olarak dönütler alabilmişlerdir. Materyale ilişkin örnek iki arayüz Şekil 1 (Figure 1) ve Şekil 2 (Figure 2)'de verilmiştir. Bu sürecin daha etkili olması için öğrencilerin birbirlerine "*niçin böyle düşünüyorsun*", "*bu nasıl böyle oluyor ki… anlamadım*", "*hayır… bu doğru değil, çünkü…*" gibi sorular yönelterek bilgilerini sorgulamaları sağlanmıştır. Veri toplama aracı olarak uygulama sırasındaki kamera ve ses kayıtları kullanılmıştır. Ayrıca veri kaybını önlemek için her bir grubun yakınına çekim yapabilecek birer kamera yerleştirilmiştir. Toplanan tüm veriyi çalışmada vermenin mümkün olmadığı anlaşıldığından, her gruptan birer kesitin verilmesine karar verilmiştir.

Sürecin başında başarılı öğrencilerin dersin işlenişi konusunda biraz endişeli ve meraklı oldukları gözlenirken, düşük ve orta düzeyde başarılı öğrencilerin bu arkadaşlarını ve bilgisayar ekranındaki uygulamaları merakla izledikleri gözlemlenmiştir. Birkaç uygulamadan sonra tüm öğrencilerin süreci benimsedikleri ve kendi aralarında materyali ve materyale gömülü oyunları ve soruları tartıştıkları gözlemlenmiştir. Bu süreçte araştırmacılar da gruplara sordukları "*bir tavla oyununu kazanmak için ne yapmak gerekir", "sizce tavla oyununu kazanmada şans faktörünün etkisi var mıdır? Niçin*" şeklindeki sorularla hem tartışmayı derinleştirmişlerdir hem de uygulamanın hedeflediği odaktan uzaklaşılmamasını sağlamışlardır. Bu gibi sorular kısa bir süre tartışıldıktan sonra öğrencilerden ekrana gelen aşağıdaki soruyu tartışmaları istenmiştir:

İki kişi bir oyun oynuyorlar. Birinci kişi bir para atıyor, para tura gelirse oyunu kazanıyor. Ikinci kişi ise klasik (123 456) bir zar atıyor, zar çift (2,4,6) gelirse oyunu kazanıyor. Bu iki oyuncudan biri siz olsaydınız parayı mı yoksa zarı mı seçerdiniz? Niçin?

A grubunda bu soru aşağıdaki şekilde tartışılmıştır.

Büşra: *Zarı seçerdim*

Kübra: *Niçin?*

Büşra: *Çünkü, zarda üç şansım var ama parada bir şansım var.[Sessizlik]*

Araştırmacı: *Büşra sadece istenen olayların sayısını karşılaştırmaya odaklanıyor değil mi arkadaşlar.*

Musa: *Yanlış! Çünkü biz olayların olasılıklarına odaklanmalıyız.*

Büşra: *Hayır… [Sessizlik]. Bilmiyorum …*

Musa: *Bu olayların her ikisinin de gerçekleşme olasılığı* $\frac{1}{2}$ *değil mi?*

Kübra: *Evet…*

Büşra: *Nasıl, yani?*

Musa: *Para atma deneyinde zaten iki durum var, ya tura ya da yazı gelecektir.*

Hep bir ağızdan: *Haklısın.*

Musa: *Yani tura gelme olasılığı* $\frac{1}{2}$*'dir.*

Büşra: *Ama bir zar attığımızda altı durum sözkonusu …mmm…bir parada …*

Musa: *Bir zar atma deneyinde 1,2,3,4,5,6 biri gelecektir.*

Hasan: *Doğru…*

Musa: *Zar atma deneyinde çift gelme olasılığı* $\frac{3}{6} = \frac{1}{2}$

Büşra: *Hmm… demek ki olayların olasılığına bakmak gerekiyor.*

Büşra paradaki tura sayısıyla zardaki çift sayıların sayısını kıyaslayarak hata yapmıştır. Lamon (1999) Büşra'nın yaklaşımını parça-parça ilişkisi olarak tanımlamıştır. Oysa bu soruda parça-bütün ilişkilendirilmesinin yapılması gerekiyordu. Büşra'nın bu yaklaşımı benimsemesi, örnek uzay bilgisinin yetersiz olmasıyla ilişkilendirilebilir. Nitekim literatürde birçok çalışma (Bezzina, 2004; Chernoff, 2009; Gürbüz, 2010; Keren, 1984; Nilsson, 2007; Polaki, 2002) olasılık kavramlarının anlaşılmasında örnek uzay kavramının önemli olduğuna vurgu yapmıştır. Sürecin sonunda, Büşra'nın parça-parça ve parça-bütün ilişkisini anlamasında BDİT'in etkili olduğu söylenebilir.

…

Diyalog devam ediyor…

Araştırmacı: *Bilgisayardaki materyali kullanarak deney yapmaya ne dersiniz?*

Hepsi bir ağızdan: *Evet! [heyecanla]*

Tüm öğrenciler materyali kullanarak birçok deney yaptılar.

Musa: *Sonuçlar konuştuklarımızı doğruluyor.*

Araştırmacı: *Nasıl? Bize açıklayabilir misin?*

Musa: *Ben 1000 deney yaptım. Para atma deneyinde, 461 kez tura geldi ve 539 kez yazı geldi. Zar atma deneyinde, 164 kez 1, 157 kez 2, 165 kez 3, 180 kez 4, 170 kez 5 ve164 kez 6 geldi. Çift gelenlerin (2, 4, 6) sayısı 157+180+164=501 ve tek gelenlerin (1, 3, 5) sayısı ise 164+165+170=499'dur. Bu ise bize sonuçların yaklaşık olarak eşit olduğunu gösteriyor (501≈499).*

Araştırmacı: *Şimdi, para ve zarı kullanarak Hasan, sen 500, Kübra sen 2000 ve Büşra sen 10000 deney yapın ve elde ettiğiniz sonuçları tartışalım.*

Deneyler yapılıyor …

Bu bulgular ve aşağıda özetlenen sonuçlar, literatürdeki araştırmaların (Baker, 1999; Dewiyanti, Brand-Gruwel, Jochems ve Broers, 2007; Monteserin, Amandi ve Schiaffino, 2010; Rowntree, 1992; Van Amelsvoort, Andriessen ve Kanselaar, 2007; Veerman 2000) sonuçlarıyla paralellik göstermektedir.

- BDİT stratejisi rahat ve eğlenceli bir ortam sağlamıştır.
- Öğrenciler sınırsız deneyler yaparak ve bu deneylerin sonuçlarını kendi aralarında tartışarak anlamlı öğrenmeler gerçekleştirmişlerdir.
- Bu uygulamalar öğrencilerin kavram yanılgılarını belirleme ve gidermede etkili olmuştur.
- Bu sürecin, matematik dilinin ve iletişim becerisinin gelişimine katkıda bulunduğu söylenebilir.

BDİT'in etkisini arttıran diğer faktörlerin ise, etkili rehberlik ve az sayıda grupla çalışma olduğu düşünülmektedir. Bu tür uygulamaların etkili olması için sınıf mevcutlarının azaltılması ve öğrenme ortamlarının sınıfça tartışmaya uygun hale getirilmesi gerekmektedir.