This study explores the informal statistical inference (ISI) experiences through the graph construction of young children regarding the pictograph as one of the conventional data displays. Within a case study approach, interviews with 7 years-old children were conducted through a module including a task. The task designed here presents a statistical context structure which focuses on the eye colors observed in a class. Through forming a pictograph, children responded the questions in order to investigate their informal inferential reasoning ability. Findings revealed that young children’s graph construction experiences could be expressed as a construct of ISI. Besides, it was concluded that the integration of context with data helped their graph construction since they analyzed data within the context.

Keywords: Statistics education, early childhood, informal inferential reasoning, pictograph

Introduction

There is a common understanding that statistical concepts can be developed from the beginning of early childhood education. As well as statistics education is a relatively newer issue for most of the school mathematics program worldwide (introduced during the 1990s in the US) (Friel, Curcio and Bright, 2001), it is even more newer for early mathematics classes. However, accepting the primary and middle school level students’ difficulties which they experienced with statistical concepts, statistics education is widely considered important. Suggested practice of statistics from the kindergarten to fourth grade level includes both descriptive and inferential statistics such as data collection, data organization, description of data, reading the data, interpretations of data displays (bar graph, pie charts, pictographs, line graphs, etc.) (Watson, 2018). Pictographs are one of data displays which young children are engaged in order to informally investigate data. However, inferential reasoning level is left mostly on the higher levels of education, and that makes the statistics education in lower grades as composed of only computations on some basic graphical representations (Makar & Rubin, 2009). However, according to Makar and Rubin (2009), there are lots of ways to introduce ISI and to develop the ISI abilities to young children as well, such as making predictions, or generalizations or providing a situation where young children can use probabilistic language.

Informal statistical inference (ISI), or informal inferential reasoning (IIR) is a relatively newer concept, that is defined as “the way in which students use their informal statistical knowledge to make arguments to support inferences about unknown populations based on observed samples” (Zieffler, Garfield, Delmas & Reading, 2008, p. 44). They outlined the IIR framework as containing the following three main components: IIR includes (1) making inferences but not using formal statistical procedures, (2) using prior knowledge (formal knowledge of descriptive statistics, but
informal knowledge making inferences about different samples, use of statistical language) and, (3) using arguments, and making claims about populations while using the evidences gathered from samples belonging to those populations (Zieffler et al., 2008, p. 45). In fact, it could be claimed that inferential reasoning embraces an understanding of graph construction. This claim was reflected in the task design suggestions for researchers in order to study informal inferential reasoning as well (Zieffler et al., 2008).

Based on the framework characterized by Zieffler et al. (2008), Makar and Rubin (2009) tried to “broaden accessibility to inferential reasoning with data” and they highlighted three key principles: (1) generalization beyond the data through making predictions, estimations, etc., (2) data usage as evidence in order to make generalizations; and (3) use of probabilistic language in order to explain the generalization drawn while being aware of the level of certainty (p. 85). Authors saw these three elements as observable abilities which comprises the informal inferential reasoning of young children.

Makar and Rubin (2009) points to the findings regarding students’ incapability of making statistical inferences while constructing graphs. The graph construction concept as a construct was addressed as a part of graph comprehension and it was stated that graph construction was less-explained issue as compared to other constructs of graph comprehension (Friel et al., 2001). The graph comprehension highlighted by Friel et al. (2001) treats the data displays as “discovery tools” rather than focusing on the calculations of the data represented in the data display (p. 132). Therefore, the current situation of statistics education cannot be claimed to do so because of it is full of simple arithmetic calculations based on descriptive statistics such as mean, median, etc. This is also valid for early childhood level of education, since most of the activities regarding statistics asks questions like: “what is the most/least …. observed?”, “what is the difference between the most and the least … observed?”, etc. Hence, such questions degraded statistics education to basic arithmetic and trivializes the significance of context in which answers to such questions could be meaningful only. Focusing on the context maybe the most distinguished property of statistical reasoning rather than mathematical reasoning. Therefore, serving statistical context-structures to young children is important so as to provide them with meaningful statistical inferences while staying in the context.

There are some studies which focuses on the issue from other perspectives. For example, McPhee and Makar (2018) studied with young children in their studies in order to investigate statistical inscriptions they formed. Their approach can be evaluated as a problem solving since it begins with a problem and children were expected to make a data analysis based on inscriptions they formed at the end. They concluded that such kind of teaching approaches can be helpful for children in order to develop desired attitudes towards statistical thinking. Another study had a focus on data representations of primary level students (grade level 4) freely while using a catapult (Fitzallen, Watson, Wright & Duncan, 2018). The researchers present their study in a STEM context and hence they also offer an effective STEM activity which can be used in statistics education. Since the data representations observed during their study were diverse and mostly case-value plots, authors concluded that they couldn’t analyze the data. However, students who selected the frequency bar charts had the opportunity to see the data in an expected manner. This result strengthens the over-emphasis on bar graphs (only in categorical variable) with a focus on calculations.
Here in this study, towards the graph construction, young children were aimed to experience with ISI while focusing on what data tells about beyond the basic calculations. My aim is to present also the ISI abilities of young children so as to claim that statistics education should not be based on the calculations from the very beginning. Since much exposure of basic descriptive statistics calculations in lower grades makes statistics education to be treated in a narrowed and limited understanding, it is currently suggested that foundations of statistical reasoning and ISI can be introduced to the young learners as well (Paparistodemou & Meletiou-Mavrotheris, 2008). Therefore, this study is significant that its findings would reveal the exploration of young children’s ISI experiences while constructing a pictograph and what we can learn from their experiences as researchers in order to better introduce them to ISI experiences.

An important issue which was highlighted by Makar (2018) is the statistical context-structures. They are addressed as one of the core notions which young children need to experience in their kindergarten classes. She concluded that statistical context-structures are valuable for teachers while making them precautious about directing questions and emphasizing the informal statistical reasoning while leaving the formal statistical reasoning for the higher-grade levels for students. This suggestion from Makar (2018) in order to develop statistical reasoning abilities of young children is to present statistical context-structures instead of technological tools regarding their capabilities of using a dynamic software such as TinkerPlots. Hence, they can provide a learning environment which Konold and Pollatsek (2002) addressed as a new period of learning while offering an extra-ordinary data analysis experience for students. As Makar and Rubin (2009) pointed out that such efforts are for understanding the beyond the data, which is aimed in fact for all levels of statistics education, not only beneath the data as it is done in early and primary mathematics classes, nowadays.

With an emphasis on ISI of young children here, conventional graphs (pictographs) were selected in a pre-designed statistical context-structure. On the contrary to what is done regarding statistics education as currently, informal statistical reasoning should be addressed without moving away from the context and without making differentiations based on the grade level. Therefore, the main aim of this study is to explore these experiences of young children with ISI through graph construction in statistical context-structures.

**Methodology**

This study uses qualitative efforts to respond its research question and analyze the data. The design and the data collection period are based on the case study approach (Yin, 2017). The unit of analysis is each participant and then this study can be named as multiple-case study design. Through the convenient sampling, there were 7 children (3 girls and 4 boys) as participants who are 7 years old in a private school. They were from two first grade classes and were chosen by their teachers, by paying attention to their talkativeness and sociability with a stranger.

Main data collection tool is the interview. Each participant was interviewed nearly 15-20 minutes. Interview was voice-recorded and transcribed verbatim. During interview, a module designed by the researcher used in order to direct questions to the participants. These are the questions presenting a statistical context-structure which will help to explore the experiences of young children’s ISI
through graph construction. Through the module each participant was also expected to form a pictograph. During their graph construction, researcher read the questions in the module. At some moments of the interview, researcher took photographs which shows the graph representations of the participants during that moment.

The module specifically presents a context of a class of a child named Ali. There are small colored movable pieces showing the eye color of each child in the class. Participant was expected to organize these onto the paper. In addition to the questions included in this module, which is shown below in Figure 1, researcher asked some further questions for example, “why did you organize in this way?”, “Is there any better way to organize them?”, etc. including the questions regarding descriptive statistics as well. The questions were generated according to the three principles which Makar and Rubin (2009) introduced and they were directed to the children without moving away from the context, which are eye colors observed in Ali’s class.

![Module A – Used in the interview](image)

**Figure 1: The module used through interview**

**Findings**

The aim of this study is to explore young children’s ISI during graph construction. All of the participants completed the module while keeping the context in mind. As a prior finding, it was observed that use of statistical context-structures in early childhood level of education helps children to think between the lines of context. Then, researcher observed the principles of ISI framed by Makar and Rubin (2009) from children’s module experiences.

All of the seven children correctly gave responses regarding descriptive statistics namely the frequency or the sample size, through the questions related with the most or least seen eye color in Ali’s class, and the number of people in the class. This also strengthens the fact that their familiarity with such kind of frequency-based activities.
Regarding context, there were lots of talk about it. At the beginning of graph construction, participants asked to me how many eyes s/he should use for one person in Ali’s class. I directed the question “does a person have different eye colors or not?” and they decided to use one piece of eye label for each person. Real eye colors were also discussed. For example, 2 girls asked to me why I didn’t prepare hazel or honey-colored eye labels. They expected to see different blue eye labels. But they were the same since I prepared blue colored eye label in order to represent all real blue eye colors. This means that they were aware that blue eye color can be different from one person to another, in terms of color tone. This shows that they are in context and they could discuss the reality of phenomenon as well.

Through the graph construction, I asked them to organize the eye colors seen in Ali’s class in order to easily realize the most and least one without counting them, for example. Their initial organizations were in Table 1 below. Four children properly formed the pictograph and they explained that they are grouping the eyes according to the colors in order to understand easily. Some of their explanations are as follows:

<table>
<thead>
<tr>
<th>Participant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hira</td>
<td>“We can make groups [according to color].”</td>
</tr>
<tr>
<td>Derin</td>
<td>“You can see which one is most and which is least in this way.”</td>
</tr>
</tbody>
</table>

Although 3 of them (Kerem, Toprak and Emin) were not observed to form a proper pictograph initially, they used different groups of eye colors, they were mostly trying to put them in a pattern. Toprak’s representation, for example, shows a nice pattern which can be seen from Table 1.

**Table 1: Initial graph constructions of participants**

Then, I asked them secondarily to organize the eyes in a different way or in order to realize the least and most one easily. Their explanations are varying differently as in the following:

<table>
<thead>
<tr>
<th>Participant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hira</td>
<td>“We can make a different organization, for example [she changed the direction of the cards.” (she rotated the labels 90 degrees.)</td>
</tr>
</tbody>
</table>
Emin: “We can do a different graph. For example, we can put the numbers on the bars.”

Poyraz: “We can make a different graph, we can change the places of the bars, in descending order, for example.”

Kerem and Emin grouped the eyes according to the colors and constructed a proper pictograph in their second trials, as can be seen from the following Table 2. When I asked whether we can do a different organization, they both realized making groups of same colors. Although, Toprak also grouped the eyes according to colors, he couldn’t represent them in an expected way. He used the bars in the same height and largened the width of the bars instead of extending the bars. Toprak, could not see different eye colors as to be comparable with each other. That is, he did not realize what a representation means or for what purpose it can be used. It can be said that he didn’t understand the idea of constructing a graph and its necessity.

Table 2: Secondary graph constructions of Kerem, Emin and Toprak

Regarding the first question in the module, participants tended to think about the eyes in the module in comparison to their real classes. At first, 2 of them thought that Ali, mentioned in the module, was real since they have a same-name classmate as well in their classes (Ali is a common name for boys). Some of them were trying to match the eyes with their friends. For example, Hira said that her class contains only one person whose eye color is blue. This can be explained that they tried to understand Ali’s situation while putting themselves in Ali’s place. At the end, participants were observed that they understood the context as ‘Ali’s class’ which is an imaginary one. That is, they could imagine Ali’s class as it should be.

It could also be said that participants could grasp what these data tell them or not. All children could talk about Ali’s friends, such as ‘Ali has 5 friends who have green eyes.’ Before asking the third question in the module, they could talk about these descriptive properties of Ali’s class as a context.

The task designed and used in this study could be said a nice example of a suitable one which can be presented to first graders. The context was attractive for them and they were observed as they were enjoying.

**Discussion**

This study showed that there is a necessity of being exposed to different statistical contexts through class activities. Based on the findings regarding the first question of the module, children were observed to making comparisons with their real-life situations in order to understand the context
presented for them. This shows that they were not accustomed to such questions in which contextual thinking brought to be forefront. As Ben-Zvi and Aridor-Berger (2016) concluded in their study that children need different types of contexts through different class activities. They need to imagine about the context which they were presented.

Regarding Makar and Rubin (2009)’s framework, it could be concluded that children could make sense of use of data as evidence and tried to make generalizations. The comparisons they made with their real classes strengthen this conclusion. For example, comparing the number of blue-eyed students in their class with Ali’s class, some of them said that Ali’s class has more than usual. They tried to think of the classes they have seen so far. In their school, there are two first grade classes and both class members are familiar with each other. It can also be said that the participants could analyze the data in the context (Ben-Zvi & Aridor-Berger, 2016). Therefore, the task used in this study shows a nice example of providing children to integrate data and context with each other.

The role of graph construction as another construct of informal inferential reasoning can be seen very well here in this study. Almost of the participants could realize the need to see the categories (eye colors) in the given context comparatively. Therefore, they put the first eye labels of each color in a line (horizontally or vertically) as a reference line. They were aware that their representation showed only the comparisons of categories. Suggesting some ideas like putting numbers on each bar, or reversing the graph as upside down or from right to left showed that their understandings are clear for the meaning of representation. That is, they were focused only on what conclusions could be drawn from a data representation, the pictograph in this case. Only one child focused on the pattern which he saw and he couldn’t show the comparisons of categories although he responded correctly to the questions related descriptive statistics in the module. It might be because of his interest to the patterns with some objects.

This study overall could be concluded as a contribution to the existing framework for ISI of young children through graph construction. It is explaining the graph construction as a construct with an informal inferential reasoning perspective. The findings outlined here could be concluded as a contribution to the existing suggestions of integrating the statistical context structures into early childhood mathematics education with the use of data. Lastly, the findings of this study give an opportunity to the researchers in order to criticize the current situation of statistics education which was outlined above in the first part of the paper. The overall conclusions might offer a chance to deal with the ISI in the very beginning of school period of students, as well.

References


