

THE IMPACT OF A TEACHER'S ATTENTION DERIVING ON STUDENTS' STATISTICAL DISCOURSE

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Improving students' learning has been emphasized as a major purpose of formative assessment. In formative assessment, teachers need to gather information from students and provide feedback. Several methods for facilitating students' learning through formative assessment have been raised in statistics education. However, published research on how teachers understand students' responses and provide feedback during the statistics teaching and learning process is not sufficient. In statistical reasoning, since it is important to consider which aspects students focus upon in a given data set, teachers should guide students' focus through feedback or questions. Watson (2007) emphasized 'attention' as a way of facilitating students' mathematical development by teachers' actions. This study aims to suggest a way of implementing formative assessment which is applicable in statistics education through the concept of attention. We present the impact of a teacher's attention deriving on the statistical discourse and reasoning of 11th grade students.

INTRODUCTION & THEORETICAL BACKGROUND

One of the essential purposes of assessment in education is to improve students' learning. It is shown in the definition of assessment, which is "the collection, evaluation, and use of information to help teachers make decisions that improve student learning (McMillan, 2008, p.8)." In formative assessment, teachers need to gather information from students and provide feedback (Garfield, Zieffler, Kaplan, Cobb, Chance, & Holcomb, 2011). Several methods for facilitating students' learning through formative assessment have been raised in statistics education. Minute papers are the most widely used method, which are composed of questions that require students to answer what they understand or misunderstand in a classroom (Burrill, 2007; Reading & Reid, 2006). The students' responses are helpful to the teacher in designing the next class. Posner (2011) mentioned introducing the PARLO (Proficiency-Based Assessment and Reassessment of Learning Outcomes) system, which focused on the role of the students, to implement formative assessment. However, research on how teachers understand students' responses and provide feedback during the statistics teaching and learning process is not sufficient.

In statistical reasoning, it is important to consider which aspects students focus upon in a given data set. This would be the basis of designing instruction or determining the level of students' reasoning. Pfannkuch (2006) extracted ten elements of reasoning that teachers paid attention to when they compared boxplots by informal inferential reasoning. While Pfannkuch approached the focused aspect practically, there are studies that present the components of informal inferential reasoning theoretically (e.g. Zieffler, Garfield, delMas, & Reading, 2008). To implement formative assessment from the view of emphasizing the aspect paid attention to, it is necessary for the teacher to guide students' focus toward the appropriate target through the provision of feedback or questions and to facilitate their learning. Watson (2007) emphasized 'attention' as a way of facilitating students' mathematical development through teachers' actions. By actions, she meant ways in which individuals direct changes in objects, whether these are abstract ideas, visible things, or symbolic constructions. Watson expected the shift of orientation towards concepts, methods, properties, and relationships to occur as a result of directing learners' attention.

This study aims to suggest a way of implementing formative assessment which is applicable in statistics education through the concept of attention. For investigating the way of teachers' implementation and the phase of changes of students' statistical discourse, we are going to adapt four properties of discourse: word use, visual mediators, narrative, and routines, presented by Sfard (2008). We present the questions that teachers can provide attention based on the properties of discourse that teachers can provide attention. Then the impact of a teacher's attention deriving on the statistical discourse and reasoning of 11th grade students is shown.

METHOD

Participants

The participants were a secondary school teacher and ten secondary school students in grade 11. For the informal inferential reasoning, students should have formal knowledge about foundational concepts, such as distribution or average, and informal knowledge about inference (Zieffler et al., 2008). In the Korean statistics and probability curriculum, basic statistics and probability concepts are taught and learned from grades 1 to 10; thus, the secondary school teacher and grade 11 students are appropriate. For the active participation, the teacher is required to understand and have an interest in the importance of implementing formative assessment through interaction with students. The students are required to actively participate in group works and classroom discussions. We chose a teacher and students who fit these qualifications.

The Task

Burrill (2007) suggested that tasks that allow discussion enable the teacher to provide feedback. She stated that open-ended tasks have the potential to reveal a great deal about students' conceptions and misconceptions. Such tasks have the characteristic of multiple access points for students with different levels of understanding. Zieffler et al. (2008) suggested three types of tasks that can be used to study the nature and development of informal inferential reasoning: estimate and draw a graph of a population based on a sample; compare two or more samples of data to infer whether there is a real difference between the populations; and judge which of two competing models or statements is more likely to be true. Based on Zieffler et al.'s task classification, we chose tasks for informal inferential reasoning from previous studies and modified each task to fit Burrill's suggestion. In this paper, we focused on the task of comparing two boxplots to infer whether there is a real difference between the populations. A part of the task is shown in figure 1.

Suppose that there is a special summer camp for track athletes. There is one group of 100 athletes that run a particular race, and they are all pretty similar in height, weight, and strength. They are randomly assigned to either group A or group B. Group A gets an additional weight-training program. Group B gets a regular training program without weights. All the students from both groups run the race before and after the camp, and their times are recorded, so that the data could be used to compare the effectiveness of the two training programs.

1. Estimate the median of recorded time of each group before the camp.
- Group A: () sec / Group B: () sec.
2. If *there is no effect* of the additional weight-training program, what would you expect to see in a comparison of the two graphs? Draw the boxplots of each group and explain the drawing as much as possible.
3. If *there is an effect* of the additional weight-training program, what would you expect to see in a comparison of the two graphs? Draw the boxplots of each group and explain the drawing as much as possible.

Figure 1. Informal inferential task (modified from Zieffler et al., 2008)

Procedure

For investigating the impact of a teacher's attention deriving on students' statistical discourse, the teacher presented a task of informal inferential reasoning (Figure 1) and had students pay attention to the fundamental concepts and elements of informal inferential reasoning during group works and classroom discussions. Then, we needed to see the phase of changes of students' statistical discourse. Thus, one of the researchers and the teacher designed and modified the task after having a discussion, and formed some questions which would be appropriate based on students' prior knowledge and level by thought experiment. The forming of questions was done by using the concept of attention presented by Watson (2007). The questions should guide students' focus toward the fundamental concepts and elements of informal inferential reasoning. The

questions were related to the properties of discourse presented by Sfard (2008). First of all, for the word use, there are studies which show students difficulties in using statistical terms properly because of lexical ambiguity (e.g. Kaplan, Fisher, & Rogness, 2010). Therefore, the teacher should derive the lexical ambiguity or informal words to clarify. Second of all, for the visual mediator, students sometimes have different foci when they see the same graph. By asking them to refer to the focus of the graph precisely, students can show the developed statistical discourse. Third of all, for the narrative, teachers should give students opportunities to expand the object-level narrative by having students present variations of concepts, or to develop the meta-level narrative by having students focus on the way or the rule of the object (Sfard, 2007; 2008). Finally, for the routine, teachers should describe students' actions or emphasize what they are doing since students need to reflect on their own actions (Sfard, 2007; 2008). Also, consideration of the context and inferential situation is important for the change of meta-rule, which is appropriate for statistical discourse (Ben-Zvi & Sfard, 2007). Table 1 shows ways of questioning based on those four points.

Table 1. Ways of questioning focusing on attention and properties of discourse

word use	re-voicing students' words or statements that need to be specified or formalized
visual mediator	deriving clarification in referring to a part of a graph or visual expression
narrative	deriving diversification of concepts deriving objectification of concepts by focusing on the way or rule of the object
routine	deriving consideration of students' own actions deriving consideration of the context deriving consideration of the inferential situation

Data Collection and Analysis

The teaching experiment consisted of 6 50 minute classes. This study is focused on the fifth class. During the class, there were group works, with three or four peers in each group, and classroom discussions. Every process of instruction was recorded into audio and video files. The data collected consisted of the questionnaire, audio files, and video files. For the data analysis, all class audio and video files were transcribed. From the transcriptions of students' discussions, data were analyzed on four properties of discourse: word use, visual mediator, narrative, and routine. The researchers focused on how students' statistical discourse and learning had changed.

RESULTS

Two episodes are presented from the classroom discussion. The discussion is about question 3 in Figure 1. In episode 1, the result of group 1's discussion is presented by a member of group 1 (S4). Group 1's graph is shown in Figure 2. Episode 2 focuses on the discussion of how Group 1's graph really shows the effect of the additional weight-training program. The classroom discussion is led by the teacher.

Episode 1

01 S4: Well, the meaning of having an effect is... decreasing the time, since it [decreased time] shows the effect. Our group fixed the median of each group as the same, as 12. Thus group B is drawn in the same way [pointing to the boxplot of group B]. Since group A has an effect, *the record would be faster* [pointing to the boxplot of group A], so I drew the crowded one on *this side*.

02 Teacher: *This side?*

03 S4: Well, *from Q1 to the median, in group A. So I drew it in this way.*

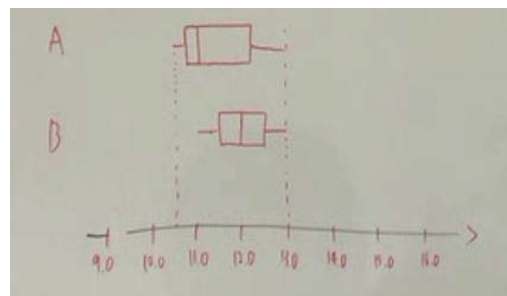


Figure 2. Group 1's answer for question 3

- ...
- 07 S9: What is the reason that the data points are crowded in the front side?
- ...
- 14 S9: Shouldn't it be crowded evenly, then?
- 15 S4: Well, you mean that the graph goes down overall?
- ...
- 18 Teacher: The graph goes down overall?
- 19 Students: The records would be faster.
- 20 Students: Decreased.
- ...
- 29 S9: ... Since the graph of group A is crowded in the front side, doesn't it mean that only the upper-ranked athletes reduce the record, and the lower-ranked athletes are not affected?
- 30 S7: Not all of the 100 athletes... no, not all of the 50 athletes should be affected.
- 31 S9: That's right. But if there are more athletes who are not affected, then the median should be moved to the backward.
- 32 S7: The meaning of there being an effect is that there are more athletes who are affected, even though it depends on the person.
- 33 S9: If the effect is assumed, then I think every athlete should be affected.
- 34 S6: We cannot guarantee that only the upper-ranked athletes would be affected.
- 35 Teacher: Everybody, what are we doing?
- 36 S6: We are guessing the whole.
- 37 Teacher: Do we just see only the graph of A? What is the conclusion? The additional weight-training program has...
- 38 Students: An effect or not.
- 39 Teacher: Has an effect or not. So, what we need to do is to infer that there is an effect, right? How did S4 draw the graph? What is the main feature?
- 40 S8: The front side is smaller [than group B]. The front side of the box is smaller [than group B].
- 41 Teacher: The front side is smaller? So?
- 42 S8: It is crowded.
- 43 Teacher: It is crowded.
- 44 S8: The probability of being crowded is big.
- 45 Teacher: So, what is the reason for drawing in that way?
- 46 S4: Since they participated in the additional weight-training program. And it is reduced overall [pointing to the boxplot of group A].
- 47 Teacher: Oh, it is reduced overall? It?
- 48 S4: This one... This graph of group A.
- 49 Teacher: This graph? Do you agree everybody? Can it be happen?
- 50 S8: Yes.

In episode 1, some examples of changes in students' statistical discourse followed by the teacher's questions are given. For the word use, the teacher re-voiced or restated the students' words which were ambiguous or informal; then students tried to modify the diction in their discourse. For example, in line 15, it is hard to understand the meaning of S4's expression, and it does not show whether S4 reasoned well or not. Following the teacher's restatement of the student's expression in line 18, students used the proper words relating to the context. Also, in line 40, S8's expression only shows that the area of the box in the graph has shrunk. S8 only focused on what he could see superficially rather than on what he could imagine from the box. However, following the restatement of the teacher in line 41, S8 could change the words which were approached by the distributional aspect. By stating that "it is crowded," he imagined data points in the box. Line 42 is not appropriate as well since it is a definite expression and does not fit the inferential situation. But after the teacher restated it in line 43, S8 could use a probability expression.

For the visual mediation, the teacher asked about the exact point that was not expressed precisely in students' words. For example, in line 01, S4's expression "this side" was clarified to "from Q1 to the median, in group A." following the teacher's questioning. In addition, in line 46, S4 did not present the subject of the shrinking precisely. But he clarified it as "this graph of group A" following the teacher's questioning.

Meanwhile, the focus of discourse from line 29 to line 34 was about the boxplot of group A. Students' interest was why only the upper-ranked athletes in group A had reduced records or

whether all of the athletes would be affected or not. However, according to the question, it is important to infer that there is a difference between the two groups, which means that the additional program does have an effect, by comparing the boxplots of group A and B. Thus, the focus should be moved from the boxplot of group A to the boxplots of both group A and B. The teacher noticed the focus of students' discussion, and asked them what they were doing in line 35. It gave the students the opportunity to reflect on their actions and made the discussion of line 29 to line 34 the object. Since the context of the comparison should be added, it is important to change the former discussion as an object. After line 40, discourse of the boxplot of graph A by comparing it to the boxplot of graph B is presented. This shows the change in narrative, since it objectified the students' actions for the latter discussion.

Episode 2

- 01 Teacher: We are trying to infer whether the additional weight-training program has an effect or not. Let's see the picture [Figure 2] and think about it. You can think it critically. How do you think?
- 02 S7: There might be an effect.
- 03 Teacher: There might be an effect. Why?
- 04 S7: Since the median is faster.
- 05 Teacher: Since the median is faster. Since the median is faster. You focused on the median, right? Anything else?
- 06 S6: The record of the upper 50%.
- 07 Teacher: The record of the upper 50%? We did not draw the graph A and B separately. We drew them at the same time. Besides, what does group B represent?
- 08 Students: The group which was not affected.
- 09 Teacher: The group which did not participate in the additional weight-training program, right? We drew the graphs at the same time, right? We didn't draw them separately, right? Why did we draw them at the same time?
- 10 Students: To compare.
- 11 Teacher: Do the comparison. Well, the median, upper 50% of what? S6?
- 12 S6: The upper 50% of group A is...
- ...
- 18 S6: Well, group A is crowded there [from the smallest value to the median], whereas group B has its upper 50% having a lower record.
- 19 Teacher: So, it shows the effect, S6?
- 20 S6: Well, it seems to have an effect.
- ...
- 26 Teacher: We talked about median, and the upper 50%. Anything else? Can we compare using another focus?
- 27 S7: The minimum.
- 28 Teacher: Compare, compare. The minimum?
- 29 S7: The slowest record.
- 30 Teacher: The slowest record? The minimum?
- 31 S7: Since the slowest record did not change...
- ...
- 41 Teacher: So, S7 thinks that the additional program does not have an effect. Right? Does anyone think that there is no effect? Does anyone think that there might be no effect?
- 42 S8: There might be no effect...

In episode 2, there are many changes in the students' narrative, following the teacher's questioning. In order to discuss whether the graph presented by group 1 [Figure 2] showed the difference of two groups or not, the students needed to infer based on the comparison standard. However, in line 06 and line 27, the students only mentioned simple terms like "the record of the upper 50%" or "the minimum" and they did not show how each standard was operated as the comparison standard. Since the teacher wanted the students to use them when they made comparisons in their statistical discourse, she mentioned the comparison situation in her questions (line 07, line 09, line 11, and line 28). And in line 11, she derived the clarification of the answer. As a result, the students could expand their narrative by relating to the comparison context, as

shown in line 18 and line 31. In addition, it also shows the change in routine since the question derived consideration of the context and the inferential situation.

Meanwhile, in episode 2, the teacher's effort to change the focus of the discourse allowed the students to reason in a different way. Starting from the inference which focused on median by S7 in line 04, the focus went to the upper 50% by S6 in line 06 to line 26, and then the focus went to the minimum of each group by S7 in line 27. The teacher suggested the question of "Anything else?" when a certain discourse seems to be over in each situation (line 05, line 26). As mentioned above, from line 06 to line 26 and from line 27 to line 31, there were changes in discourse of using the term of "the upper 50%" and "the minimum." The teacher knew the proper time to change the students' focus. By asking a question which derived the new focus, the teacher changed the focus to one that the students should pay attention to in their reasoning.

DISCUSSION & CONCLUSION

In this paper, we suggested the ways of questioning using the concept of attention, which can be used during the statistics teaching and learning process. In addition, through the teaching experiment, we examined that students' statistical discourse showed some changes as a result of the teacher's questions. Although the ways of questioning are not completely developed yet, and they need to be elaborated upon, we see the possibility that teacher's questioning focusing on attention and properties of discourse can be a way of implementing formative assessment in the classroom.

In the study of Ben-Zvi & Sfard (2007), the researchers showed that statistical discourse could be developed by the leading discourse of a student of relatively higher level. This study shows that by assigning the leading discourse to the teacher in the classroom, it can be used as a way of improving students' statistical discourse, that is, statistical learning, and as a way of implementing formative assessment through interaction between the teacher and students.

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