Exploring the statistical practices in classroom: STEM teachers' experiences using dynamic data analysis technology.

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In the 21st century, schools have been increasingly expected to raise students prepared for a world of quantities and uncertainty. As statistical practices become an important skill for every individual, researchers and educators work on ways to translate the methodologies of professional statisticians in the teaching and learning environments. Technological tools are helpful in translating statistical investigations into the classroom. The purpose of our research is to understand teachers' experiences about integrating statistical practices into their STEM lesson plans by using LabStar, a dynamic data collection and data analysis tool. Findings were investigated under four categories: personal development, in-class implementation, views about the mobile application and the tool, and statistical investigation environment. Future research was recommended to investigate teachers' professional development opportunities to integrate meaningful statistical practices in their lesson plans.

Keywords: Statistics education, statistical investigation, dynamic data analysis technology.

Introduction

In the Big Data era being competent in making data driven decisions in all aspects of daily life is inevitable. Many decisions in politics, economics and social sciences are based on thorough analysis of data. The omnipresence of data requires individuals with strong analytical and reasoning skills who can base their decisions on their inferences beyond the data in the way that professional statisticians do (Frischemeier, 2020). However, international reports point out the lack of individuals, who demonstrate necessary skills to cope with Big Data even at the tertiary level (Manyika et. al., 2011; Puang-Ngern, Bilgin, Kyng, 2017). From this point, practice of statistics became a crucial element to integrate in primary and secondary school curricula.

In 21st century, schools have been increasingly expected to raise students prepared for a world of quantities and uncertainty. With the availability of data from variety of sources and in a variety of formats students are required to manage the complexities to reach data driven conclusions (Makar & Rubin, 2009). Statistics, therefore, has become an essential element of school mathematics curricula of many countries (e.g., Australian Curriculum, Assessment and Reporting Authority, 2015; Common Core State Standards Initiative, 2010; Ministry of National Education, 2018).

As statistical practices become an important skill for every individual, researchers and educators work on ways to translate the methodologies of professional statisticians in the teaching and learning environments. Statistics education is becoming an agenda across many levels of schooling. Debates about how to help students gain an understanding about statistics requires us to think about the nature of statistics. Statistics is about carrying out statistical investigations on a specific statistical question to understand a phenomenon. Statistical investigations are based on exploring the variation, by engaging data collection, data representation, data reduction, level of certainty and informal inference practices (Watson et al., 2018).

Statistical investigation is recommended to be the focus of the statistics teaching-learning activities in classroom contexts. The parts of the investigation process have been also included in mathematics curricula starting from elementary grades. As the practices of statistical investigation become a part in mathematics curriculum, the role of the teachers comes forth. Teachers are expected to design authentic contexts where students can engage in data collection, analysis, and informal inference processes. Research also underlines the importance of teacher knowledge on statistics and statistical thinking to design effective learning experiences for their students (Rodrigues & de Ponte, 2020).

Technological tools are helpful in translating statistical investigations into classroom. Dynamic technologies that allow students to experiment with data collection and analysis techniques were started to be researched in terms of the opportunities they provide for statistical practices (Meletiou-Mavrotheris et al., 2008).

COVID-19 caused schools to get shut off, which made STEM and statistics education to be conducted on online portals. This probably led to changes in the teaching method and the environment. The aim of creating statistics literate students that use statistics tools, software, and can interpret the data became the priority. In order to fulfill this aim, collaboration, communication and multidisciplinary studies that involves data science and education must be addressed.

Based on this rationale the purpose of our research is to understand teachers’ experiences about integrating statistical practices into their STEM lesson plans by using LabStar, a dynamic data collection and data analysis tool. Teachers were provided with educational videos about integration of statistical investigations into STEM lesson plans and the use of LabStar tool. After watching all the videos teachers implemented the STEM lesson plans, designed with authentic statistical investigation tasks. Our aim is to explore the lived experiences of teachers about the implementation of these lesson plans. Our research questions are:

- How STEM teachers contextualize statistics and mathematics into daily life problems using STEM integration?
- How STEM teachers perceive their roles in terms of integration statistical investigation in STEM education?
- How STEM teachers evaluate the educational videos in terms of designing and implementing statistical investigations in STEM lessons?

Methodology

The research used a phenomenological method among qualitative research designs. The study group is four STEM teachers who used statistical investigation practices in their classrooms during 2020-2021 Spring Semester. T1 was a middle grades mathematics teacher, T2 and T3 middle grades science teachers, and T4 was a high school physics teacher. They implemented STEM lesson plans integrated with statistical investigation in various grades and with different disciplines in the center of the lesson plan. They used LabStar as a dynamic data analysis technology. LabStar is a dynamic data collection and analysis tool. It works with the physical tool and the mobile application. The mobile application can be used also separately from the tool by analyzing open resource data. All teachers and students had the LabStar mobile application, one of them (T4) had both the physical data collection tool and the mobile application. Teachers used data from open resources to analyze in their in-class implementations. Before the implementation they were provided with training videos regarding ways of using dynamic data analysis technology in their STEM lesson plans.

For data collection we conducted face-to-face interviews with the teachers. To ensure a prolonged relationship, interviews lasted at least 60 min. Audit groups were formed within the research group and member check processes were planned to ensure trustworthiness. Researchers are also using peer-debriefing during data collection and analysis phases. STEM lesson plans and field notes of the teachers were used as data sources to ensure triangulation in data collection. For data analysis, interviews were transcribed, and thematic analysis was conducted by using constant comparative method. Because multiple coders will analyze the transcripts, the methods for ensuring intercoder reliability were used. Documents of teachers (lesson plans and notes) will be analyzed by content analysis. Data analysis will be finished in November 2021.

Findings

Analysis of the interviews and the documents revealed myriad findings about the experiences they had during integration of STEM education into their classes. Findings were investigated under four categories: personal development, in-class implementation, views about the mobile application and the tool, and statistical investigation environment.

Personal Development

This theme emerged as the participants mentioned about the training they have received and research they have done before and/or during applying a STEM activity in the class. All teachers expressed that the educational videos that they have watched before attending to the classes, helped them to learn and grasp the nature of the application before introducing the software to the students. One of the teachers, T1, commented that "With the help of the videos, especially the fourth one, we were able to lead the students in the right direction". T2 added that: "The videos were sufficient, I received STEM education last year, I knew nothing. In a year I learnt about STEM education and some of the questions were given to us that are in the videos."

Furthermore, some of the teachers had to get help from various resources because they felt that they did not have sufficient knowledge.

> I am a science teacher, when I was studying on it, I got help from my husband who is a mathematician, (I asked about) upper quartile, lower quartile etc. I taught students with the information I got from him too. I also got tremendous help from the educational videos. (T3)

This view also showed that teachers also had an opportunity to discover knowledge related to other disciplines. A teacher had sufficient technological knowledge and even integrated STEM education to work with a software simultaneously.

> I thought about what I could do, I set up a meeting with the students from 9th and 10th grades. A student said that we should test its (LabStar's) accuracy. We tested it and it was accurate. We conducted two experiments, firstly

> we created sound waves and measured its decibel. We have a software called Scratch; we created the sound waves then integrated it with LabStar. The data were almost equal. We used it to compare the sound waves, their wavelengths. I found it usable for advancing in physics. It is a nice software (T4).

The teachers started their lessons with introductory activities to motivate students. T1 stated "We asked the students about number of cases of covid-19. Then we led them to the relevant website.". T2 added "I asked the properties of microscopic life forms. With the feedback I have received, I mentioned about the bacteria then gave the table". Although T2 did not ask anything before the lesson, she let the students explore by themselves. This allowed the students learn by discovery.

> I did not ask anything, I let them do experiments because I was experimenting too. When I asked what do you see, they told me that the wave is increasing, I asked how a wave can increase? Is it on the direction x or y? Then we got data, but now they tell numbers instead. Are they increasing or decreasing? We call them data. As the waves increase, the numbers increase, what do we call it? Wavelength. (T4)

Some teachers worked as a group to put out the lesson plan.

> We worked as a group. I usually build interdisciplinary relations with mathematics, but I always get help from the biology. We do gas pressure, sound waves, they are all about biology. There were machines in STEM laboratory, I used the distance sensor there. (T4)

The teachers explained that they plan to apply their knowledge into their other lessons too.

> Maybe it is not possible to apply it to all topics, since physics, chemistry and biology are different. But for velocity, race, order of the velocity, density of a matter, there can be data and it can be commented on. I think that it could be integrated depending on the area. (T2)

T4 also asserted that, "I will use it to explain illumination density. I have the topic movement on 10^{th} grade, location, distance, translocation, I will use graphs. It is fun to make students active in 9^{th} and 10^{th} grades."

In-class implementation

This theme has emerged as the teachers expressed their experiences about the application of a STEM lesson in a class. A problem occurred because of the mismatch between the current grade's curricula and the statistical terms in the tool. T1 claimed that "Some terms were troublesome since they did not fit to my class". T2 added that "In my opinion it was not suitable for 5^{th} graders, the terms mode, median in the graphs". T1 further explained that: "The students didn't know the terms and their meanings since the terms do not fit to fifth grade's curriculum. They did not understand it because they did not learn it, and I did not pre-teach the terms."

Some teachers had problems because of the students' technological skills being insufficient. T1 claimed "Some students found it hard to transfer data to an Excel sheet", She further said "At first they found it hard to create a table. There were students who did not know the shortcuts".

The teachers explained that they were not able to hold the attention of the whole class nor make all students participate in the activity. T2 claimed that "If you have 50 students, only 10 students give positive feedback. There were students who did not download the mobile application or participate in the lessons".

The teachers who had the mobile application but not the physical tool claimed that they could have reached to more students if they had the physical tool to collect real time data. Some teachers observed that some students were interested in the lesson:

> There were many students who were interested in the lesson. There was data related to basketball, it drew the attention of male students. If the topics were different there could be different things. But I received positive reactions, some students asked if they could collect and analyze another data. (T2)

Views about the mobile application and the tool

This theme has emerged as the teachers stated their views about the mobile application and the tool that they have used to carry out their STEM lesson plans.

Another challenge was born because of the language of the application being English. This was a common problem amongst all teachers. T1 stated “The only problem was the application being in English, it could be in Turkish. If they don’t know English, they need to use translation”. Some schools did not receive the physical tool, but they only had the mobile application. The teachers believe that they need the tool itself.

> It would be better if we had the tool. For instance, in a 7th grade, I have conducted a lesson about darker colors absorbing light thus being colder. I used heat and light sensor simultaneously to observe the graph. It was a brilliant lesson. I did not have such fun in any lesson before. So, it would be better if we had the data collection tool. (T3)

T2 claimed that. “It is vague for 5th graders, for a fifth grader, the tool being here and the process of collecting the data is necessary. It needs to be concrete”. There were some problems that originated from the application and technology use. Overall, the teachers were satisfied with the experience they had with LabStar. T2 claimed “The teachers can use LabStar easily and create STEM lesson plans.”, T4 added “LabStar can analyze data, it is accurate and fun”.

Statistical Investigation Environment

The teachers have different expectations about the statistical terms that the students must know and express in a statistical investigation environment.

> It is crucial to be able to read the graphs, where is the peak, what is the increment this month, being able to comment, creating a cause-and-effect relationship is important for science. Mathematical interpretation, peak point, outliers. I believe that LabStar application is related to mathematics at most. (T2)

> The students do not know how to read the graphs, they cannot even read tables. They have learnt how to do it; I believe that that is the significant contribution. (T3)

The teachers claimed that STEM integration made observing statistical terms easy.

> In the topic waves, there are fundamental notions. Frequency, amplitude, and wavelength. You can create a sinus wave, you can observe the wavelength, then we can measure it. We talked about range and modes, we created 2-3 waves, x wave and y wave then we compared them. At first, they talked about their image, then we compared them as data. (T4)

Some students were not interested in terms related to statistics. When teachers were asked if the students asked about statistical terms, T2 said “No, they did not ask. In 6th and 7th grades the activities would be more efficient. However, since the total number of lessons are less in 5th grades, it limits us.” T1 added that, in online environment, only the students who are passionate about mathematics asked, but we did not have a whole-class discussion. Since the number of curious students were low, they contacted us through private messages. (T1)

Discussion

The teachers reported that by seeing the graphs live, students grasp the concepts of mathematics and statistics in a fun and interactive way. This may be because in most cases formal statistics teaching leaves students in a confused state as most of the time they are not able to apply the theoretical knowledge into real life (Bakker et al., 2017), whereas the fun factor comes into play with the activities. The teachers worked together with other teachers to set up a multidisciplinary context, this is because developing mathematics, and integrating it with the other disciplines in STEM is the main aim in STEM education (Li & Schoenfeld, 2019). Even though context integration should be used to teach STEM (Kertil & Gurel, 2016), the teachers most of the time failed at integration of STEM with other disciplines, they mostly worked on their own disciplines. Therefore, creating statistical investigation environments was evaluated to be essential (Anderson & Li, 2020).

Teachers used real data from various resources to analyze with the mobile application and believed that real life situations are shown with excellence by using the tool and mobile application. it is probable that go prepare students to real world and its requisites, they feel that real life problems should be the main scope of the curriculum and the lessons in the schools to provide problem solving skills in which they need to provide a solution, a model to achieve the goals clearly (English & Watters, 2005). The teachers preferred experimenting with the students mostly because In the 21st century, using computers and being proficient is necessary and in STEM education, for the most of the educators experimentation is the preferred way rather than the computation (Li et al., 2020). The teachers dealt with problems that arise from the statistical terms, but they were caused from the curriculum not including the related terms, and the teacher’s lack of self-awareness to do a pre-teach session. Future research was recommended to investigate teachers’ professional development opportunities to integrate meaningful statistical practices in their lesson plans.

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