

STATISTICS IN MATHS CAMPS

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Abstract: It is generally agreed that statistics is an important discipline to be introduced at school level. However, only small components of the subject and a narrow scope are introduced at primary and secondary school level curriculum in Kenya. This paper discusses the emerging prominence of statistics sessions at Math Camps in Africa. It shows how maths camp student participants have developed the knowledge and skills to support further learning of important statistical concepts. This has involved hands on sessions where students interact with real data sets.

INTRODUCTION

Statistics plays an important role in many aspects of life ranging from education to environment. This subject has potential to impact society if it is understood and used well. In most African countries, Statistics appears as one of the topics taught in secondary school mathematics curriculum. In Kenya, Statistics is introduced in form two (around age 15), starting with examples of data collection where data of about 10 cases are used. The students are taught about grouped data and frequencies before calculating measures of central tendencies, that is, mean, mode and median. The students are taught to produce line graphs, bar graphs, pie charts, pictograms, histograms and frequency polygons from the data. The duration for covering the above is two weeks. Probability is introduced in form three (age 16), where concepts of theoretical probability, calculating probability using possibility diagrams, addition and multiplication of probabilities and calculating probability using tree diagrams are taught theoretically. In form four (age 17), learners are introduced to cumulative frequency and measures of variation. A lot of emphasis in the content delivery is on learning formulas for the different statistics. In this way, interesting and relevant statistics content is limited in the curriculum. Most students end up graduating without a good understanding of the statistical concepts. Some even wonder why they learned statistics.

As a way of promoting statistics among secondary school students and teachers across Africa, we have always included the subject as a theme at our annual Math Camps since 2011. The Math Camps are week long residential camps where high school students are exposed to interesting and relevant Math topics that they would not encounter in school. The camps take place during the school holidays and the usual practice is to bring the students into a University environment. Here they get to interact with volunteer lecturers, researchers, teachers, Math educators, post graduate and undergraduate students who facilitate the sessions. The camps focus on learner centered teaching methods and popularize Statistics to dispel the myth that Math and Statistics are hard. The sessions create opportunities for students to develop statistically and promote the integration of technology into teaching and learning of statistics.

Currently, the Maths camps run annually in Kenya, Ethiopia, Ghana, UK and Tanzania. They have run since 2011 in Kenya, 2014 in Ethiopia, Ghana and UK and 2016 in Tanzania.

MATHS CAMPS APPROACH

We have done lots of things at different Maths camps however, the camp environment is often set up explicitly to encourage collaboration, groupwork and learner participation. Data, interactive statistics software, group projects to explore statistical ideas and participatory learning are some of the tools and methods that have been used for exploring Statistics themes at the various maths camps. In some camps camp participants have used their own data and in some other camps they use open data in the sessions. The main sessions on Statistics have featured the sub themes like; Data collection, data visualizations and probability.

Data collection: Students are introduced to data collection on reporting day. In some camps they fill a questionnaire on tablets or computers upon arrival, usually administered through the

Open Data Kit (ODK). Information collected include student names, schools, level in school and other variables like their best subjects, height and weight. The students again fill a mid-week survey where they give feedback on the sessions they've had. Finally, they fill an end of the camp survey where they give similar information to the mid-week survey. Many students interact with a tablet for the first time during as they fill the questionnaire, and enjoy this process. This data is also used in some Statistics sessions making students appreciate the process of data collection. In addition, facilitators get invaluable feedback to use when running subsequent sessions.

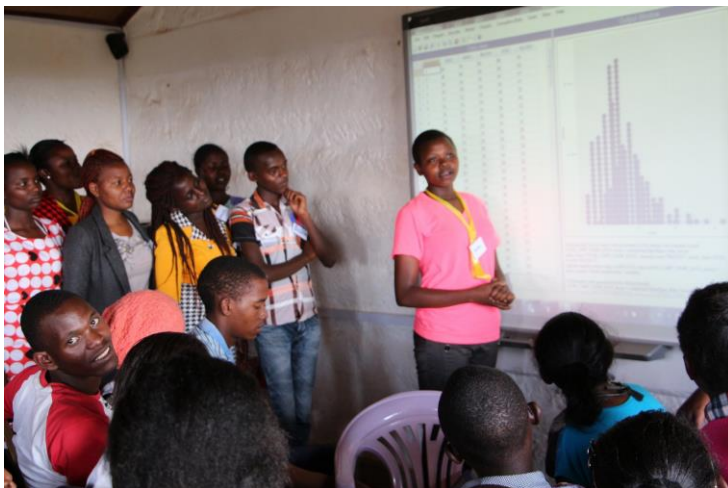


Figure 1: Students present their analysis results during a Maths camp Statistics session. The software they are using is R-Instat

The students studied the qualitative data they had collected and generated themes from it. They then applied a variety of statistical techniques to organize and review their quantitative data. While this can involve more advanced statistics, they often got what they needed by generating simple summaries from their datasets. The most challenging part of the process was often identifying how to link two unrelated data sets (e.g., average temperature and average rainfall) to a third dataset (e.g., ideal crops for a specific location). The students are given freedom to learn an analysis software to use while being guided by facilitators. In 2013, students in the Ethiopian and Kenyan Math camps used pivot tables and graphs. In 2016 however, most students preferred using the R-Instat to analyze their datasets and explore the datasets in the library. Some students generated summaries for rainfall totals, maximum and minimum temperatures using daily data from 1969 to 2010 using one of the datasets in the library.

The students then learn how to interpret analysis results. Students were cautioned to be cognizant of bias that may be present. For example, in the 2016 Kenyan Maths Camp, students collected data from locals on crops grown, crops that can do well and also the preferred food crops. Bias was observed in the food crop planted since it was a region where many prefer *ugali*, a cake made from maize flour, and most of the students came from there. While it was important to not let their own biases influence their interpretation of the data, the opinions, biases and perceptions of students were an important lesson. The students would then share their outputs and presentations after the analysis. These representations took the form of summary reports and graphics since they could easily interpret them. Facilitators focused on what students had learned from the data and identified as a resulting need. It made sense to share a list of the crops that are grown compared to the crops that the community's dietary concern.

Other Visualizations: Gapminder World is a software used to display interactive and animated graphs showing indicators of development for every country of the world. We used Gapminder in Maths Camps to show students how to interpret data from graphs and the importance of computers in visualizing and analyzing large data. The session would start by watching a video by Hans Rosling where he gave the history of 200 countries over 200 years in four minutes. Volunteers facilitated discussions on how to interpret time series graphs, how to identify trends and how graphs could be used to tell story of a country. The students then learn the software and find answers to open questions like "Which country has the highest life expectancy today?" and "Which

The Math camps offer ideal opportunities to introduce students to new technology. One Statistical tool introduced was R-Instat. This is a free to use statistical tool developed by the African Maths Initiatives for teaching and research purposes. R-Instat can be used to generate descriptive statistics, conduct regression analysis and generate graphs. A special climate menu was added to help students analyze available daily climatic data.

country is better to go for the purpose of studying?” Students were given the opportunity to create their own questions, investigate graphs to answer their question and present their finding to the rest of the participants. Through this students discussed the relevance of such data, who could benefit from using it and what impact could be made if people had the skills to draw useful information from the data, for example for governments, NGOs and tourism.

Probability: In the 2014 Maseno Math Camp, students explored the concepts of relative frequency and probability. The students worked in pairs, each pair being given a bag with five bottle tops (3 green in color, and 2 orange in color) in it. Without looking into the bag they were asked to predict how many of each color there are by randomly selecting then replacing one top at a time, recording each result thereafter discussing and explaining their own thinking. This way they developed their own understanding of relative frequency theory of probability.

RESULTS

Using data from the latest Kenyan Maths Camp in April 2017 only three out of the 48 students mentioned Maths as their favorite subject. Within a week, ten had mentioned Maths among their favorite subjects. As has been noticed in several camps, the students’ perception of Maths shifted from “very difficult” subject to “average” and “easy” subject (Table 1). Studying variability in data helped students understand the importance of looking for patterns in data. In the pre-survey questionnaire none of them related Maths to pattern recognition. At the end of camp survey seven of them related math to finding patterns in different datasets. In general, on a scale of 1 – 5 with 5 to indicate extremely interesting and educative and 1 the converse, students rated the statistics sessions as 3.8.

Table 1: Students rating of Maths difficulty before camp and at the end of the camp, using 2016 data from the Kenyan Maths Camp 2017

Difficulty score	Pre-Camp responses (%)	Post-Camp responses (%)
Very difficult	5.9	0.0
Difficult	12.0	8.3
Average	62.0	56.3
Easy	15.0	20.8
Very easy	5.9	14.6
Total	100.0	100.0

The facilitators always collect qualitative information in form of student journals. In the 2013 Ethiopia maths camp, during the preparation week a local volunteer who is also a staff of a university in Ethiopia said “*Our country needs so many revolutionaries to change the system.*” Also in one of the surveys, a teacher suggested that training has to be a continued process. These are very strong and deep statements. Students make comments like “*I want to continue with this math camp every year*”, “*If it is continued a lot of people can learn*”, “*The idea should be spread to all African people*”, “*I had the greatest time while learning maths*”, “*It should be done by other universities too*” another student said “*it is not a must to cram large formulaes for you to know maths*”

In addition, pioneers maths camps participants had moving stories as captured below:

Evans

Evans attended as a student participant in his last year of school in 2012 and he had this say after the statistics session, “*Mathematics extends beyond the classroom understanding of multiplication, addition, subtraction and even division. I got a better understanding of this when I attended the first maths camp in 2012 Maseno Maths camp. I used to consider Mathematics as a boring and irrelevant subject, with nothing interesting apart from being a teacher.*” He also had this to say “*If classroom math was that boring what about a math camp? I really had low expectations on that first day of the camp. I knew it was going to be the usual cramming of*

formulas accompanied by examples from nowhere. But by the end of that day, I could see how most things involve math. The method of teaching was that nice and easy to understand. From the mathematical games, computer sessions, mathematical thinking, statistics sessions and inspirational talks from the organizers, it was a fully packaged math camp. The simple and real examples used in explaining the concepts made me see how math was that simple and real.”

Specifically on the statistics session using Gapminder he said *“The integration of computer sessions within the camp was really a nice idea. I was able to interact with Geogebra, Gapminder and even Scratch. The active participation of everyone made the camp lively and friendly for learning new things. I could now understand the interesting part of mathematics and was even able to try simplifying math problems that seemed complicated.”*

Before coming for the maths camp he had not thought about doing a course in maths related subject because he was performing very poorly in the subject. After attending the maths camp he had this to say *“The short video by Hans Rosling demonstrated using Gapminder became the turning point of everything; I got more interested in statistics. But I am really happy that I attended the camp three months before taking my final high school exam. This is because it led to improvement in my math grades and even grades of other subjects. Now, am proud to say that am taking Applied Statistics in my undergraduate studies at Technical University of Kenya.”*

Cabrine

“My journey to success started in 2011 when I attended my first maths camp. Since then I have had a different story to tell about my performance in Maths and generally all subjects. The camp gave me a wider perspective in Maths and helped me discard the negative stereo-type that revolves around Maths. The several sessions and activities done helped me to acquire a positive attitude towards the subject and with time I became a Maths guru at school. My school also became a beneficiary following the installation of maths packages into the school computers.”
Cabrine is now doing Economics and Statistics course at University of Nairobi

CONCLUSION

Secondary school students in Kenya and beyond can understand more complex ideas in statistics using real world data. In a short period student interest and motivation to study statistics and Math increased. This was done through active involvement through collaboration, group work, group projects and use of real world data. The students showed more robustness in working with their own data, and enjoyed the whole process of data collection to analysis. Rather than using formulae to introduce concept, the approach was reversed so that computers did the hard analysis while they learnt the interpretation. The students focused on learning the concept as it is not easy to produce a useful result if the concept is not well understood.

The importance of facilitation could not be overemphasized. By guiding and not doing the work for students we allow them room to facilitators were guiding and not doing the work for the students. This helped students who were meeting the computers for the first time to be able to do complicated climate data analysis. Given the complex nature of problems the volunteers help the learners express relationships of the many relevant variables. As long as the students feel that their instructors will listen to and engage them in discussions, the benefits to their sense of belonging to the subject will be great.

We strongly believe that inclusion of real world data would greatly improve the lessons hence the students' attitude towards statistics. In this era of big data, using data to teach would generate better understanding of problems and equip students with useful statistics skills. New Zealand is one country that is leading on this. Students have shown to enjoy statistics if the teaching methods are engaging/interactive/relevant. Furthermore, they have shown to enjoy not just statistics, but even university content like modelling.

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