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Reading and Writing the World with Statistics: Critical Understanding for Social Justice

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ABSTRACT

This study addresses the need to develop secondary students' critical understanding of descriptive statistics for social justice. Students worked on non-routine problems called Model Eliciting Activities, which require students to make interpretation and conclusion of meaningful real life situations. The modeling lessons had four Model Eliciting Activities (Safe Water, Millennium Dam, Football & Tourist) so as to allow students to 'express, test and revise' their models iteratively in an engineering way in multi-disciplinary areas. The objective of the study is to explore how can students develop critical understanding with the aim of living together in the world that is 'survival with dignity' using a pedagogy of Modeling Approach on cross cutting issues of a society on a unit of descriptive statistics. Quality Assurance Guide instrument was used to assess students' models on Model Eliciting Activities. A transformative study design was used to look into students' critical understanding qualitatively. Descriptive statistics and content analysis were used to analyze the data on students' reports on Model Eliciting Activities and on projects. Though students found Model Eliciting Activities cognitively challenging tasks, they constructed different models working in a team collaboratively towards social justice. In conclusion, the findings of the study showed students more likely can enhance their critical understanding of descriptive statistics towards social justice working on relevant non-routine tasks like Model Eliciting Activities and doing projects on their own themes.

Key Words*:* Statistics, Modeling Approach, Model Eliciting Activity and social justice

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1. INTRODUCTION

Modeling is getting recognition in Mathematics Education for advancing students' understanding of a concept (Doerr & Lesh,2003), (Sriraman & English,2010). However, little is known about Socio-critical Modeling that uses mathematics or statistics as a critical tool for analyzing and solving socio-cultural problems. A Modeling Approach in the study integrates Contextual and Socio-critical Modeling Perspectives for teaching statistics through problem solving and, therefore; justifies the statistics rather than treating it as a means to an end.

The nature of problems beyond classroom demands educators to give students interdisciplinary problem solving experiences. Here is an important question to ask: 'How far do the problems which exist in textbooks help to achieve the above aims?' An ongoing debate in mathematics education for several decades pertains to the extent to which low-level to high-level activities should be used (Chamberlin,2008,p.1), (Chamberlin, 2010, p.52),(Schoenfeld,2004). Analysis model is suggested by (Chamberlin, 2010, p.52) for decision making for teachers to select problem solving tasks for low level and high level learners. Based on this model, the content analysis is made on the current Ethiopian Grade Nine mathematics textbook on statistics unit which is published by Ethiopian Ministry of Education in 2010.

The percentages of exercises and word problems tasks in statistics unit in Ethiopian Grade Nine mathematics textbook are 68% and 27% respectively. Although Ethiopian education policy and documents on mathematical curriculum recommend that there should be relevant problem solving activities on socio-cultural issues, the percentage of statistical problem solving tasks (4%) in Grade 9 textbook is very low and non-routine statistical problem solving tasks are almost non-existent. Researchers have indicated that covering the text book is the most common teaching practice in Ethiopia instead of engaging students with rich problem-solving tasks (Asgdom,2009).

This may lead teachers to use simple textbooks problems and as a result, students couldn't develop cognitive abilities to solve problems in novel situations. Furthermore, students need to develop their critical understanding of statistics to solve socio-cultural problems. A study by (Asgdom,2009) has found that the practice of Ethiopian Education mostly focuses on knowledge acquisition, or what UNESCO calls "learning to know," to the detriment of other useful purposes, learning to do, learning to be and learning to live together.

The central aim of Socio-critical Modeling is developing students' critical understanding of the surrounding world with emancipator perspective (Kaiser & Sriraman, 2006). This perspective emphasizes the role of mathematics in society and claims the necessity to support critical thinking about the role of mathematics in society.

This study was conducted at West Oromia Region schools (School A and School B; pseudonyms) in Ethiopia based on grade 9 secondary mathematics school curriculum

which had one unit of descriptive statistics with 22 period allotments. The researcher choose this research site for a number of reasons. First, the researcher had familiarity of the study site living at the place for more than 15 years to investigate the nature of socio-cultural problems that could arise from their everyday life. Second, the study selected the two schools to show direction how it was possible to work jointly to improve the quality of education. Third, the distance between the two schools is 0.5 km, which could make the data collection process convenient.

2. MATERIALS AND METHODS

This section presents the research approach and methods used to investigate secondary students' critical understanding of descriptive statistics using a Modeling Approach. This study is informed and shaped by the theoretical influences of Contextual Modeling and Socio-critical Modeling perspectives. Given the purpose and context of the study, recognizing the theoretical research framework provides structure for explaining and justifying the usefulness and appropriateness of a study. A transformative qualitative design with a lens of two modeling perspectives was used.

2.1 Research Approach and Design

The research problem of this study led a transformative qualitative research design to be utilized. The rationale for choosing the research approach is the nature of the research question: How do students can develop their critical understanding working collaboratively on modeling activities and doing projects? For explaining the intervention (the Modeling Approach), case study design was used based on the data that included students' solution artifacts on Model Eliciting Activities (MEAs) and documents of students' projects. The case study design involved embedded multiple-case design. The case study used was explanatory type to answer the how research questions on students' critical understanding of descriptive statistics using Modeling Approach. The unit of analysis in this study was classroom practice of modeling approach, individual and teams of students who participated on the intervention to investigate how students' enhance their critical understanding of descriptive statistics.

2.2 Sampling Techniques

From the two high schools, 80 students participated in this study from two grade 9 sections. The sampling method used to select the two classes was purposive sampling. Two teachers were selected one from school A, and the other from school B based on their willingness to participate in the research. In both schools, one class of students was taught using Modeling Instructional Approach. The sampling strategy to select the participant for the interview was purposive sampling. Twelve interview participants were selected for interview on the students' projects. Students were sent an informed consent to participate in the interview based on the following criteria. The first criterion was students' achievement levels based on the pervious semester mathematics result so that students at low, medium and high achievement levels would be included in the

interview. The second criterion was sex of the student to capture some of female students' experiences on the Modeling Approach. The third criterion was on the place where the students live, rural or urban.

2.3 Instructional Design for Modeling Approach

Four MEAs were designed for this study as described in Table 1 based on the six principles of constructing MEAs (Doerr & Lesh,2003) with other statistical activities using representation systems. The MEAs had four main components: newspaper article, readiness or warm up questions, data table, and a problem. Each component serves a valid purpose and used to engage problem solvers in the task. MEAs have components, which can help students to be engaged by reading and writing the world with statistics.

Table 1. Descriptions of the four Model Eliciting Activities

Title of MEA	*Problem Context*	*Statistical Concept*	*Objectives with Social Agency*
Safe-Water	Students are asked to write a report based on 20 households data to give an awareness program for rural people how to drink safe water and keep their environment sanitation and hygiene.	Different graphs, distribution, average, little or a lot variability	To provide awareness on health and sanitation problems
Football	Students are asked to write a report to present on school min media to create awareness program and for consulting the Ethiopian football coach based on data on two football teams who plays against two other African football teams.	Center(mean, mode, and median), Distribution, Graphs	Helping others to control emotions and for creating awareness program about Ethiopian Football
Millenniu m Dam	Students are asked to write a report based on three grade 9 sections of students' data on the contribution of money to Ethiopian Millennium dam which is going to be sent by the director for the news agency.	Outliers, measure of centres (mean, median and mode) Range	Empower students on their contribution for developing their identity
Tourist	Students are asked to give reliable information based on the weather data of five tourist sites on what to eat, cloth and shoes to wear.	Distribution , measure of centre, measure of variation	Use variability in everyday life like knowing variability of weather conditions

The purpose of the newspaper was to familiarize students with the context of the problem and to develop their statistical literacy. This article required 15 minutes or so to read and provide further information for the second part of MEAs. The second part of an MEA was readiness questions or warm-up questions. These questions were designed to evaluate their understanding of their reading and basic statistical literacy ability of the media article. The third part of MEA was a problem statement, which

required students pose and solve problems on the socio-cultural problem situations. The fourth part of an MEA was usually a data table that may be used to solve the problem. After finishing the MEA, there would be other follow up activities that used system of representations and MEA extension problems.

2.4 Instruments of Data Collection

Based on the modeling cycle, a worksheet with the following probing questions were prepared and given for the students: What is the thing that the client wants you to do for him/her? How could you use the data using your model so that it is meaningful for the client purpose? Could you show how to use the statistical models to provide some solution for the problem? What are your interpretations on the models you made in question three? Do you think your statistical models enough for the client purpose and have limitations? Write your team report/letter/news.

The quality assurance Guide was designed to help teachers, researcher and students evaluate the products that were developed in response to the MEAs with the following characteristics: (a) the goal is to develop conceptual tools, (b) the client purposes are known and met, and (c) the tool must be sharable with other people and must be useful in situations where the data are different than those specified in the problem as shown in Table 2.

The Quality Assurance Guide was used to quantitatively assess students' models. The levels were designed to categorize how well students' solution artifacts or reports satisfy the needs of the client and how well they explained their reports in general way. The range of response went from level 5, where the response satisfied the needs of the client for the current situation and for other similar situations as well level1, where the response were going in the wrong direction and the team would need to rethink their reports completely.

Table 2. Quality Assurance Guide

Performance Level	How useful is the product?	What might the client say?
Level one: Require Redirection	The product is on the wrong track. Working longer or harder won't work. The students may require some additional feedback from the teacher.	*"Start over. This won't work. Think about it differently. Use different ideas or procedures.*
Level two: Require Major Extensions or Refinements	The product is a good start toward meeting the client's needs, but a lot more work is needed to respond to all of the issues.	*"You're on the right track, but this still needs a lot more work before it'll be a form that's useful."*
Level three: Require only Minor Editing	The product is nearly ready to be used. It still needs a few small modifications, additions, or refinements.	*"Hmmm, this is close to what I need. You just need to add or change a few small things."*

Level four: Useful for this Specific Data Given	No changes will be needed to meets the immediate needs of the client.	*"Ahhh, this will work well as it is, I won't even need to do anything".*
Level five: Sharable or Reusable	The tool not only works for the immediate situation, but it also would be easy for others to modify and use in similar situations	*"Excellent, this tool will be easy for me to modify or use in other similar situations-when the data are slightly different."*

For observing classroom practice, *Teaching for Robust Understanding in Mathematics (TRU Math)* classroom analysis scheme was used with permission (Schoenfeld, 2013, p.607). TRU Math rubric contains five general dimensions (the mathematics, cognitive demand, access, agency and assessment) of classroom activities. The TRU Math scheme comprised an analytic framework for characterizing essential dimensions of mathematics classroom activity and a scoring rubric for capturing their presence in instruction. Classrooms observation of the four MEAs was analyzed using the five minimal overlapping dimensions with three episodes for the MEA activities as shown in Figure 1. A typical MEA session involves the three distinct phases, which is used as episodes to analyze the classroom observation data. If an episode was greater than 10 minute, the weighted average score of two or three episodes was assigned in each phase based on the TRU Math rubric. The rubric was used as a framework taking observation note because, according to (Schoenfeld, 2013, p.607) the five diminishes can help teachers and researchers to characterize the modeling class in simple and easy language.

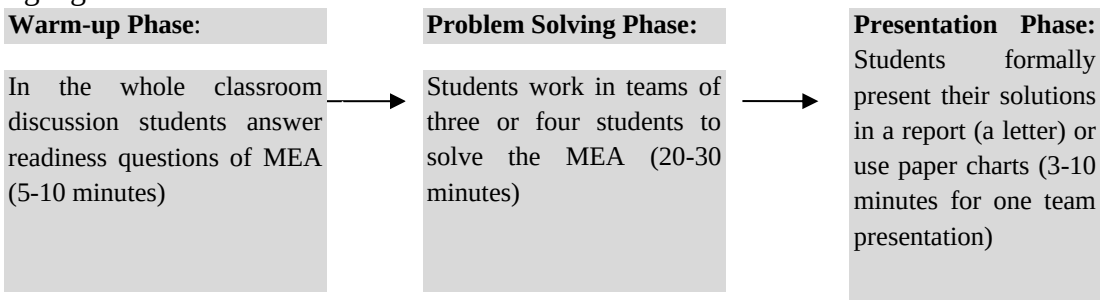


Fig.1 MEA Activities

The students wrote four homework assignments describing their work in each of the statistical investigative activities in their project works. The students consulted the teacher after completing each homework assignment to do the next stage of the subsequent homework. The homework assignments for the statistical investigation part were as follows: (1) formulating a question; (2) collecting data; (3) analyzing the data and interpreting the results; and (4) writing and presenting the final project report.

These four components provided the students a scaffolding structure to do the project. The projects were conducted by team of three or four students for six weeks.

Table 3: Four phases of the investigative project

Homework Assignment	Description of Students' writing Assignment
Formulating a Question (1-2 pages and 1 week)	2-5 research questions and a rationale for the project; students should select the topics by their own;
Collecting Data (1-2 pages and 2 weeks)	A description of how they collect data and the sample size. Students should use real data;
Analyzing the data and Interpreting the results (3-6 pages and 2 weeks)	Show 2 or more visual display of data and use measure of central tendency and variation;
Final Project (3-12 pages and 1 week)	Compilation of their previous assignment into the following: Introduction, Body and Conclusion and present their project report to students and teachers.

3 RESULTS AND DISCUSSION

3.1 MEAs Classroom Observation

The four MEAs were observed with minimum non-overlapping dimensions based on TRU Math rubric. The maximum score on TRU Math rubric is 3 and the minimum is 1. The scores of the four MEAs using weighted average were shown in Figure 2 for the two schools on the five dimensions of TRU Math rubric. The crossed inter-rater reliabilities for the four MEAs for the two respective schools were the following: MEA-1, 0.90, 0.87; MEA-2, 0.81, 0.82; MEA-3, 0.83, 0.77; MEA-4, 0.89, 0.80. The bar graphs showed the Modeling approach score lies most of the time between 2 and 3 in weighted average across the four MEAs on the five dimensions of TRU Math rubric.

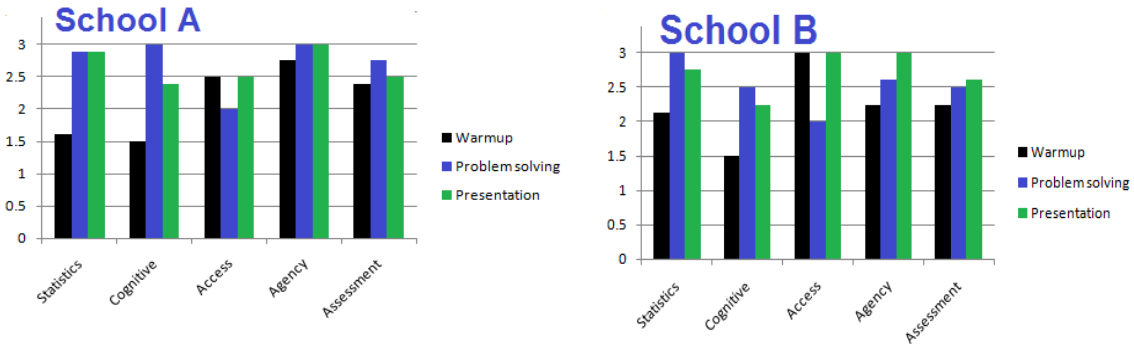


Fig. 2 Results of observation in the two schools using TRU Math rubric

3.2 The Case of Students' Models for Tourist MEA

Historical & Natural Tourist Attractions' is given as a reading homework to students and followed by readiness or warm up questions for discussion such as: What does it tells you about the temperature in Addis when it says in an average the temperature is 61 degrees Fahrenheit? What do you think the temperature in Addis Ababa might be for 6 different days in the year? Why do you make these choices? Next students were given a data table on 'the climate data for the four tourist attraction sites' and asked to write a report for the tourist describing and comparing the climate data for the four tourist attraction sites telling them what type of clothes they should wear and what type of food(drinks) they should take or have. Therefore, below are the responses of students' model at different levels.

a) Students' Models at Level 1: Two teams of students were at this level. For example, a team of students gave general information on what clothes and shoes to wear, what food to eat and what drinks to drink, but they barely used data in their report to meet the client needs. The report presented by the team of the students' model on Tourist MEA at Level 1 was given below.

Dear Tourist, it is advisable that a tourist visit a country in September because the weather condition is conducive. When the tourist wants to visit a country, he should not bring clothes for cold weather, that is, he/she should bring light clothes. The shoes should be Sandals as there is no snow in the tourist sites. The tourist needs to bring an umbrella in case it rains. Besides, the tourist should bring fast foods and cold drinks. M.D = 28+23+35+23/4 =23 M.D= /-5/+/-7/+/-5/ +/0/ divided by 4 equals 7 and M.D= 1.25

b) Students' Models at Level 2: Eight teams of students were at level 2. They used only one model, which was range to describe the average annual temperature of two tourist attraction sites out of the four sites. They used partial data of the provided data and they tried to give information on two tourist attractions sites. The reports needed further refinements using more variables and data to furnish the tourist with good information for the four tourist sites. The report presented by the team of the students' model on Tourist MEA at Level 2 was given below.

Dear Tourist, Welcome to the attractive tourist sites of Ethiopia! We would like you to introduce two historic tourist attraction sites in Ethiopia. The two sites are known as Harar and Aksum. Harer is a city protected by stone wall and it is recognized by UNESCO. The people of Harer are well known for their hospitality and love. Both Christian and Muslims have lived in Harmony for centuries. Harer is found at an altitude of 55m above sea level. The range of average temperature and rain days for a year in Harer is 5 degree centigrade and 9 respectively. Axum is a city well known for its obelisks for example one obelisk has a height of 33 meters. Aksum is found at an altitude of 2355 m which is at higher altitude than Harar. The range of average temperature and rain days for a year in Harer is 3 degree centigrade and 9 respectively. Dear tourist, Harar is hotter than Axum. You need to visit both places, because both of them are historical places and their social life and culture are interesting. Good Luck!

c) Students' Models at Level 3: Eight teams of students were at level 3 on Tourist MEA. For example, a team of students at this level used two models (range and bar graphs) to give information to the tourists using the provided data. They tried to present the data using bar graphs and range on average annual temperature on the two-tourist attraction sites as shown in Figure 3. The report and bar chart presented by the team of the students' model on Tourist MEA at Level 3 were given below.

Dear Tourist, We would like to give you reliable information about health requirement, customs, transport, time, currency, topography, etc. We would like to introduce two tourist attraction sites, which are known as Axum and Lalibla. The range of the annual average temperature of Axum is 30c and the range of the annual temperature of Lalibla is 150c. Therefore, the Lalibla temperature is hotter than the Axum temperature. Therefore, if you go to Lalibla you must wear white or light clothes, since it will be hot there. You can see and compare the temperature difference using the pair of bar graphs as shown for the two sites. Come and visit us we will *give you further information!*

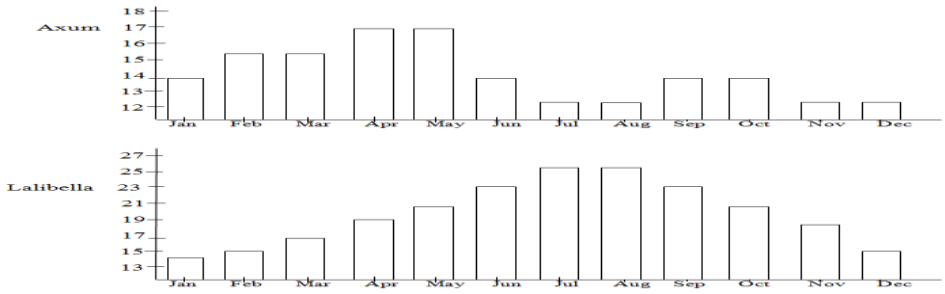


Fig.3 Team of students' Model on Tourist MEA at Level 3.

d) Students' Models at Level 4: One team of students was at level four. Similar to team of students at level 3, the team had used range and bar graphs. But the team of students gave description on the rainfall amount of the four places in addition to using the average annual temperature. The report and bar chart as shown in Figure 4 presented by the team of the students' model on Tourist MEA at Level 4 were given below.

Things to do for Tourist! There are many things that we do for tourists; they may come from a country far from Ethiopia. Thus, they may not know our local languages that we have to translate the local language for them. We can also help them by carrying their goods, food, clothes and other necessary materials. We can also use range to show the tourist sites climate variations to give information for tourists.

- Axum- has low range because 18 – 15 = 30c and rain-high = 11 mm
- Lalibela-has high variation because 28 – 13 = 150c and rain-low = 1 mm
- Gonder-has high variation because 35 – 23 = 120c and rain-low = 1 mm
- Harar-low variation because 28 – 23 = 50c and rain high = 9 mm

Dear tourists, welcome to the attractive sites of Ethiopia. Ethiopia is a country abundant with varied tourist sites, which are attractive, and you will have memories of these sites in your mind. We will say, welcome again! Now I am going to tell you about

Ethiopian tourist sites. Ethiopia has many innumerable tourist sites that it is difficult to count in short period of time. Among the well-known sites by tourism sector, we take today Axum, Lalibla, Gonder and Harar. We can see different amazing things at these places. Our dear tourists, if you want to come to Axum, you have to wear sweater, normal trousers and you need to have tea because there will be rain days. Again, if you want to come to Lalibla, you have to wear t-shirt and need to have cold water and you have to have vegetable food because this place is very hot. As we notice from the graphs, most months have high variation by temperature. At the end, please try to come to visit Ethiopian tourism.

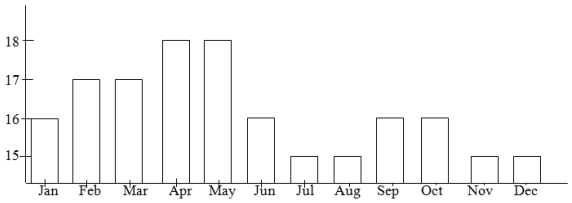


Fig. 4 Team of students' model on Tourist MEA at Level 4.

e) Students' Models at Level 5: One team of students was at level five. The team's report assumed to be sharable and reusable as the students used all the variables from the provided data and different models to describe the four tourist sites. They interpreted the data correctly within cultural contexts of the tourist sites like wearing style, social life of the people. They presented the information as if it was given in FM radio transmission. The report presented by the team of the students' model on Tourist MEA at Level 5 was given below.

This is Ethiopian FM RADIO! Dear tourists, first welcome to Ethiopia! We are happy to announce you that you will be happy for visiting Ethiopia, the country, which has several historic, cultural, and wildlife tourist attraction sites. Among the cities for tourist attractions, I will give you important information on Harer and Gonder. And Helen will give you information about the attractive tourist sites of Lalibla and Axum. Please be with us! Based on data, Harer is located at an altitude of 55m above sea levels. It is known for its people kindness and the city is called a 'love country'. Thus, this culture is closer to Brazilian culture and that many Brazilian come to visit Harar. The range of the average temperature for Harar for a year is 5 degree centigrade with medium temperature. Thus, we need to wear light clothes like traditional Harar clothes called 'dereya'. When we look at the rainfall amount, it has a standard deviation of $\sqrt{6.24}$. When we go to Gonder, it is located at an altitude of 380m above sea levels and it is a city that we found several historic and cultural places to visit. The range of the average temperature for Gonder is 12 degree centigrade for a year with hot temperature. The standard deviation of the rainfall amount of Gonder for the year is $\sqrt{2.39}$. Now, Helen will present you information on other two cities.

Thank you Hanan! I will present you information on the great Ethiopian cultural Heritage placed called Aksum and Lalibla. Axum is a place where it attracts many

tourists in the world and located at an altitude of 2355m. The range of average temperature for Axum is 3 degree centigrade, which means it is not a hot place. The standard deviation of the rainfall amount is $\sqrt{14.85}$ and you can wear whatever cloths you like. When we see Lalibla, it has range of average temperature of 15 degree centigrade. The people who lived in Lalibla often wear white clothes to reflect the sun light radiation. You could also stay there wearing light clothes suitable for the weather condition. Lalibla is located at an altitude of 74 m from sea level and the standard deviation of the rainfall amount is $\sqrt{1.34}$. Thank you for staying with us! We will meet in another program.

Using Quality Assurance Guide for the four MEAs Table 5 indicated that the percentage of number of teams of students' solution at level 1, 2, 3 and 4 were 10%, 38.8%, 45% and 5% respectively. Only one team of students' solution was considered at level 5 across the four MEAs. The majority of teams of students were at level 2 and 3.

Table 4. Number of teams' at the five performance levels for the four MEAs.

Performance Level	MEA-1 f (%)	MEA-2 f (%)	MEA-3 f (%)	MEA-4 f (%)
Level one: Requires Redirection	3 (15%)	2 (10%)	1 (5%)	2 (10%)
Level two: Requires major revision	7 (35%)	8 (40%)	8 (40%)	8 (40%)
Level three: Requires revision	9 (45%)	9 (45%)	10(50%)	8 (40%)
Level four: Useful for the specific data	1 (5%)	1 (5%)	1 (5%)	1 (5%)
Level five: Shareable and reusable	0 (0%)	0 (0%)	0 (0%)	1 (5%)

3.3. Students' Project

Teams of students selected the investigative themes by their own. They chose the themes and go through data modeling process to solve social-cultural problems on issues of health, education, culture, economic, gender inequities. Some of the themes focused on giving an awareness program to students to take some preventive cares related to health issues like dental care, body mass index, sleep, and first aid. Students had investigative themes such as learning motivation, attendance, girls' education, achievements, study and entertainment time. Teams of students also did projects on economic and transport problems, which could solve existing problems in the community with social justice agenda. Some of the themes dealt with traffic accidents and transportation problems in the town. One of the students on traffic project put her concern in the interview that she was responsible for creating awareness about traffic accidents for students with a sense of social justice.

Teams of students wrote a project report within 3 to 18 pages. Every team of students prepared a colorful poster displaying various graphs and use descriptive statistics to present reports on their projects. Two case studies of the final reports will be discussed on the next section.

The teams were trying to present their project using different styles. Three teams used dramas to present their projects. Others presented news, poems and comedy to present their reports attractively. One team of students who worked on cultural clothes had a fashion show. Three teams of students included interviews on their presentations, for example, on BMI project the students interviewed one of their team members as medical doctor to give advice on how to keep normal BMI.

Case #1 Selam's team project was about students' scores in the first semester and her team wrote in their final project report that the vision of their investigation was to see students' scores to be much better in the second semester than the previous semester. The team stated that their objective was to help students achieve high scores by initiating students to study hard. Selam said the following in the interview on how they selected the project:

When we select the theme of our project, we noticed that students' scores in the first semester are very low and we discussed how to improve the scores. When we asked some students they said, 'We wish there was no first semester and we wish if the first semester pass over unknowingly….' In our section, a female student whom we do not know stood first. We are doing this project to initiate students to score better in the second semester than the first semester (Selam: 29/4/2014).

The method they used to collect data on this project was oral survey by asking students from class to class. The team asked six statistical questions, which helped them to collect continuous and categorical data. Their data analysis used all measure of dispersion. They used visual displays such as frequency distribution tables, dot plot, bar graph, pie chart and histogram. The graphs were appropriately labeled on the axis and contain titles as shown in Figure 5 and the calculations on measure of center and dispersion of the data were accurate with correct interpretations. Selam's team wrote the following result in their report from the oral survey of 30 students:

Even if, one of the reasons for low students score was not studying hard, there are other reasons for students' low scores like work burden on female students at home, the living conditions of students, and lack of students' hope in their education. As a result, students lack any interest to learn something. In general, students, who had a lot of work to do at home, are forced not to have study time; since there is no one to help their family. Especially, this problem is common for rural female students. For urban students, the major problem is lack of interest and hope in their education, because they see college and university students at home without getting any jobs after graduation.

After pointing some of remedies for the above problems, the team started to summarize the data on last semester average using dot plot and wrote:

As the saying goes, 'If you do not sow the seed well, you can't get the harvest.' Students result for few are good and for the majority it is unsatisfactory. The range for 30 students' data score is 65 with mean score 65.2 and students' data scores standard deviation is $\sqrt{342.692}$. The standard deviation shows that there is a big variation among students' scores in the last semester.

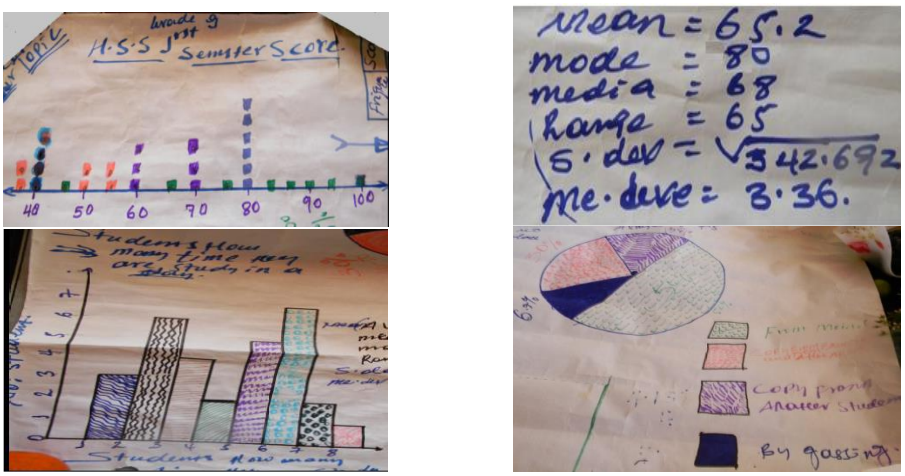


Fig. 5 Students' Scores Project Visual Displays of Data.

The other main concern of the project was the problem of copying during examinations. They reported using pie chart that 50% of the students did independently by themselves, 30% copy from exercise books and notes, 13.3% copy from other students and 6.7% did just by guessing while taking tests and examinations. Overall, all components of the project report were clearly present and of excellent quality. Among the project phases, Selam had expressed her views that data organization and analysis phase was difficult.

Case #2 Chirenet and Degenet were members of a team who did a project on Body Mass Index (BMI). Chirenet responded in the interview that the team chose the project theme for the following reason:

First, we could not estimate whether a student is normal, overweight or underweight without any measurement looking at students' body. For example looking at a student's body, we cannot say he is overweight since his weight could be distributed over his height. If he is tall and if we divide the weight by the square of his height, he may have normal BMI. Most people do not know their height, weight and BMI; that, they will be exposed for many health problems. Thus, we think the project is important for us and for many other students (Chirenet: 28/04/2014).

The team found that 50% of the students were underweight and the team worked on the project with a social agency aim to alleviate the problems giving an awareness program: If we do not weigh their weight and measure their height, then we could not know the BMI. Since we know how to use statistics, we are able to give an awareness program for others and for ourselves on how to keep our health (Chirenet: 28/04/2014).

Chirenet and Degenet team made a pie chart, dot plot, histogram and a bar graph. The team used dot plots to show the age of students, bar graph to show the sex of students and a histogram to show the distribution of students' weight. They used also measure of center and variation accurately with correct interpretation of the data. But, they had

not used standard deviation as measure of variation. Chirenet and Degenet expressed their views that among the project phases, data collection phase was difficult. In their final presentation, Degenet made an interview with Chirenet as if he was a doctor to advice students on the need to check one's BMI.

4 DISCUSSION

Students' in a team worked on multi data sets and on multi variables by reading articles and by writing reports and letters using statistics towards enhancing their critical understanding for social justice. Learning statistics is not only computing, but also involves describing and interpreting situations statistically (Lesh, 2000). The finding of the study suggests students can draw conclusion informally from data in a context on MEAs as contents of students' reports showed. The multiplicity of students' reports on MEAs showed students can develop authorships of ideas than relaying simply on text books and teachers.

The finding suggested students found the MEAs relevant to their life and they were 'hard fun' activities. Students were able to think 'outside of the subject box' in multidisciplinary areas. Statistics is at an intersection of many subjects, since all subjects will use some data to work with concepts. According to (Freire,1970), it is better if students select the investigative themes by themselves than investigative themes assigned by a teacher. Students had developed their critical understanding of descriptive statistics using statistics as critical tool towards solving the socio-cultural problems. Students were working on themes that arose from educational to economic to social life and culture problems. Students were presenting awareness program on avoiding copying during examination, keeping dental care and body weight regularly, resolving problems on gender issues and the like.

Students' were able to develop their critical productive disposition towards statistics. Students' had used different entertainment and fun using statistics as a critical tool to give an awareness program on their project themes. Students had used drama, live interview, fashion show, poems that could add value to their productive dispositions towards statistics as a tool that could be used in their everyday life to solve their own and society's problems. Students could enhance the statistical thinking, which emphasis-making conclusion based on data in a context. More importantly, the finding of the students' project showed that students at their youth age could pose and solve significant problems as social agents.

It is morally important to teach statistics using Modeling Approach to enhance students' critical understanding of descriptive statistics. It is good that people live in the world with sympathetic understanding, that is, 'survival with dignity'. The youth can be misinformed at the age of information if they did not discern the good from the bad. Even though the world is not a safe place to live for everyone in the world nowadays, it is valuable to work against dehumanization using data based evidences. Statistics may not be considered simply as useful, but also as a tool to help solve social problem. Students need to learn how to live together working in a team using statistics

as a critical tool by solving real social modeling problems in class and through project works. The findings of this study suggest students could enhance their critical understanding using Modeling Approach, since it offers a chance to work on real social problems to transform the life of disadvantaged society.

Students had been doing the projects having some kind of team sprits and the finding of the study suggest they likely develop abilities to work in teams. In the 21st century, working in multi-disciplinary areas with a team is one of the abilities students need to develop (English, 2013b), (Lesh, 2000). Students were working in teams with interdependency and helped each other towards finishing their project with preservation. They developed team sprite and learning to live together working on the projects.

There is a myth that students had fixed abilities in doing mathematics. Pedagogy with social agency could promote students empowerment beyond fixed abilities with open-ended projects. Defenders claim that if teachers teach statistics using Modeling Approach, students may not get the basic building blocks of knowledge. They assume that students need to learn first the basics, then apply what they learned later on in another statistics lessons or in application problems. Of course students need to learn a healthy dose of basic concepts and a focus only on problem solving process without skills will deter their procedural fluency; however it is possible to use Modeling Approach to enhance basic skills as well as the cognitive thinking and reasoning at the same time, since Modeling Approach enhance students' basic knowledge while they solve modeling problems. A decade of mathematics education research showed that students could enhance high cognitive thinking on 'rich tasks' without compromising the basic skills and knowledge (Schoenfeld,2004, p.256).

Defenders also may claim that modeling problems are challenging that students could not attempt to solve the problems. Neither a teacher wants to teach statistics by giving students challenging problems, which frustrate them to attempt, nor does he/she want to teach students by spoon-feeding. However, teachers need to strike a balance to teach students with some sense of challenges so that students get a chance to enhance their cognitive thinking. Even a child from the early age naturally requires some challenge; the challenge for six-month baby may be walking.

Teachers need not avoid modeling problems in the pretext of students are young that they do not need to work on modeling problems for the reason that they are challenging. But, learning theory supports that students learn well through perturbations, since human minds disallow the disequilibrium created by the challenge. Through scaffolding, students could solve the modeling problems through iterative cycles of assimilation and accommodation. The findings of the study suggest, students could undergo data modeling processes; even if, they were not experts at modeling. Social interactions in teams of students were the cause of accommodations as observed in MEAs lessons.

5 CONCLUSIONS

Traditionally statistics have been taught using a formal approach and teachers might continue with the usual practice. However, following traditions may have negative side to enhance the kinds of understanding students' need in the 21st century in an age of information. In fact, to reveal a particular practice as having a status of a tradition could not shed light on whether it is a good one or a bad one. Statistics is at the intersection of many disciplines that stakeholders need to take part for enhancing students' critical understanding for the benefit of all not just for mathematicians or mathematics educator. If Modeling Approach enhances students' critical understanding of descriptive statistics within the interest of all stakeholders, then it needs to be considered seriously to incorporate modeling problems in the statistics curriculum, instruction and assessment in an education system. Students at their youth age need to solve relevant non-routine problem solving tasks to enhance their critical understanding, which could enable them to cope up with the nature of problems in 21st century. The study revealed that students doing modeling activities and projects by reading and writing the world with statistics could enhance their critical understanding towards social justice.

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