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Informal statistical inference and permutation tests

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Background

In the Norwegian *Curriculum for the Common Core subject of Mathematics*, there are competence aims after the second, fourth, seventh and tenth years in primary and lower secondary education. In the subject area of Statistics, there seems to be little progression through the various grades, in our opinion. The relevant competence aim after Year 4 is “collect, sort, note and illustrate data using tally marks, tables and bar graphs, with and without the use of digital tools, and converse about the process and what the illustrations tell us about the data” (Utdanningsdirektoratet, n. d.).

The competence aims after Year 10 read as follows.

carry out investigations and use databases to search for and analyse statistical data and critically assess sources; order and group data, find and discuss and elaborate on the median, mode, average and spread, and present data with and without digital tools, and discuss and elaborate on different ways of presenting data and what impressions these can give. (Utdanningsdirektoratet, n. d.)

The competence aims in Statistics after Year 10 and are in textbooks often dealt with in grade 8. In the textbook *Faktor* for grade 8 (Hjardar & Pedersen, 2014, p. 110), the following problem is marked as *difficult*. A table that shows the population for each county in Norway is given with the task: “Find the top three counties with the highest population”. In terms of difficulty, there is very little progress to see from tasks given based on the competence aims after grade 4. Even if the competence aims (“analyse statistical data”) and the related document *Mathematics: Characteristics of goal achievement* seem to support a more exploratory approach leading for instance towards informal statistical inference, our impression is that the subject area of Statistics is treated superficially and poorly in textbooks.

Theoretical perspectives

There is already an extensive research literature on teaching experiments introducing statistical inference in middle school (see e. g. Watson, 2008). One common approach is to use graphical representations of datasets, often with the help of digital tools such as TinkerPlots (Konold & Miller, 2005), to make comparisons between samples and informal inferences about differences of populations. We intend to go one step further and introduce to middle school students test procedures that have theoretical justification in permutation methods (Ernst, 2004). The focus will be on the *significance* (perhaps without using this technical word) of difference of means, not just comparing means. Rossmann (2008, p. 17) suggests that “simulation of randomization tests

provides an informal and effective way to introduce students to the logic of statistical inference”. Zieffler, Garfield, Delmas & Reading (2008, p. 44) define informal inferential reasoning as “*the way in which students use their informal statistical knowledge to make arguments to support inferences about unknown populations based on observed samples*”.

Developing a teaching plan

We want to develop a teaching plan aimed at grade 8 or 9 about statistical inference focusing on experiments with realistic problems, perhaps using a design-based research methodology. As mentioned we want to include permutation tests, but they will be presented to the students in an informal way. There should be no instruction about distributions or formal methods, only an appeal to the underlying logic that we hope can be intuitively acceptable for students. This last point should be one focus point of our research. We have tried out one experiment with teacher students about comparing the weight of apples and oranges in samples and then repeatedly and randomly reassign which fruits are “apples” and which are “oranges”. How does the real difference in weight compare with the randomized differences? If there is no significant difference in weight between apples and oranges, then the real difference should not be among the most extreme in the simulation. This is an example of the logic behind permutation tests. But is it *informal* inferential reasoning? This is a question we should have in mind when developing the plan.

The details of the teaching plan are still very much in development. One idea we have is to offer the permutation tests to the students late in a sequence of lectures, where earlier in the sequence more student-driven activities, perhaps involving digital tools and graphical representation of data sets, are planned and where students are encouraged to use their own reasoning. We have done the activity with apples and oranges three times with teacher students and gotten valuable feedback. We want to develop this into a larger project involving real classroom settings.

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