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UNPLUGGED ACTIVITIES AS INTRODUCTION TO DATA SCIENCE WITH FOCUS ON ETHICAL AND SOCIAL DIMENSIONS

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Introduction

This extended abstract describes work in progress on designing learning materials that introduce data science concepts in mathematics education. The aim of the learning material is specifically to provide conceptual understanding that could facilitate classroom discussions and learning related to ethical and sociopolitical dimensions of societal applications of data science. For the purpose of the symposium, the abstract thus relates primarily to the topic AI and data science education for social good, but can also be related to learning materials.

Why

The work is motivated by the proliferated use of machine learning algorithms and AI-applications in society, and the ongoing academic and political debate about AI-ethics. An underlining idea of the work is that citizens need to be able to think critically about such mathematical models and realize that models are not necessarily objective or politically neutral. Furthermore, that mathematics education could be an area to develop such critical thinking. Thus, the work is positioned within the critical field in mathematics education (e.g. Skovsmose, 2023) which aims to make mathematics education more societal relevant by addressing contemporary societal phenomenon related to social and political justice.

How

The development of the introductory learning material is linked to a larger project that has the research aim to investigates what discourses materializes in classrooms and teacher education when critical mathematical education is applied to teaching about AI-models. The aim of the larger project is thus related to investigate how students react in teaching in learning situations. Therefore, developing teaching material is for the larger study rather a vehicle that enables data collection by providing learning and teaching situations that can be investigated. But at the same time, reasonable good material is still needed, else the classroom situations cannot be said to be about critical thinking on AI-technology.

The focus for this presentation is to report on the developed teaching material. It might be interesting on its own, also outside the larger project. The methodology for designing learning material is inspired by design based research (Cobb et al., 2003) and is used iteratively by researchers within and across sub studies. In one of the sub studies that focused on teacher education, the learning material was co-created with pre-service teachers. It was design process lasted for several months and included reading and discussing critical mathematics education (Skovsmose, 2023) articles and book chapters. The lessons were carried out with students groups, and as a part of the design process, they were continually evaluated and refined.

What

The design of the learning material follows from the intention that the material should useful as a standalone series of sessions that can be included in different mathematics courses and for different ages, but mostly aiming for upper secondary school (15-19 year olds). Mathematics courses can be dense in teaching content, so this series is limited to only two lessons. Since prior knowledge in mathematics and programming differs between students in different courses, the learning material had to be unplugged – meaning no digital tools are used – and focuses on concepts and discussion rather that programming and calculations. If a syllabus requires the latter two, they can be handled in follow up lessons, e.g. using R-Studio to see how it can be used to solve some problems from the lessons. A guiding principle of the design is that the discussions should draw from ethical dilemmas that arise in authentic societal data science contexts.

In S. Podworny & S. Schönbrodt (Eds.), *Towards Fostering AI and Data Science Literacy in Schools Across Disciplines. Proceedings of the 1st Symposium on Integrating AI and Data Science into School Education Across Disciplines (AIDEA1 2025)*, Salzburg, Austria.

The two main features of the two respective lessons will now be provided. The description follows from Andersson et al. (2024). The first activity use AI-unplugged (Lindner & Seegerer, n.d.) to introduce use data science concepts, such as training data, test data, decision trees, predictions models, etc. In an exercise students build decision tree models based pictures of cartoon monkey. Some monkey's bites, other do not, and the decisions trees should predict biting. It is up to students to find patters in the training data and to decide what variables to use in their model (e.g. appearance of eyes and mouth of the monkeys). The point here is not to train students in building models using any of the digital tools that exist for this. The point is rather for this introductory activity to utilize the unplugged approach to foreground some features of modelling such as; irreducible errors, procedural steps included in modelling e.g. variable selection, but also to use different students' solutions to illuminate contingencies in building mathematical modelling. Those contingencies and errors might seem harmless when it comes to predicting whether cartoon monkey bites (monkeys that would therefore have to be removed from an imagined zoo). However, the first lesson ends with a discussion on ethics concerning how similar models can (and are) used on humans, e.g. on important government decisions.

The second activity relates to the fact that collecting information about users' interactions on social media, provides sufficient data for models to produce predictions about the person (Kosinski, et.al., 2013). This fact is a prerequisite for the functionality of the societal phenomenon where the people's digital traces are used in marketing algorithms to direct advertisement to specific groups. That is, users' behaviour patterns, which are revealed in their digital traces, are used to predict what they might be interested in (Zuboff, 2019). If the model's predictions are better than guessing purchase behaviour at random, users' digital traces can be monetized. The learning activity starts by the teacher describing some of the work by Kosinski, et.al., (2013), including that religion, sexual orientation, political views, etc. can be predicted. It is demonstrated how Facebook users can download the data that Facebook has about them. The teacher shows a selection of his/hers authentic data. The selection of this data is made with the purpose to demonstrate the vastness and – in the eyes of the students – the unexpected types of data in this data set. For example that Facebook tracks online activities outside Facebook.com, and that data is utilized by third parties that the teacher has no relationship with, and are not sure if he/she trusts (such as an unknown company in an autocratic country). For the main part of the second lesson, a few anonymous persons' Facebook data is handed out to the students. The students work in groups to review the data and try to map the persons out, e.g. assess gender, age, what their interests are, etc. Once again, this is done unplugged and as an open unguided task in order for students to explore different principles for finding patterns in the data. In some cases, this did not lead to fully fleshed out mathematical models, but non-the-less it lead to classroom discussions on principles that are important to consider in modelling with authentic data, including both mathematical and ethical aspects. After a while, the students report their assessments, and the teacher discloses who the persons really are and whether the assessments were correct. Some plausible causes of errors are also discussed, such as the data set getting distorted if children are using their mothers' computers. The activity closes with a discussion about the relationship between data and model, especially emphasising social aspects when the data is personal data that portray habits and general behaviour.

Preliminary results and discussion

Video data from Swedish and Italian classrooms when students work with these activities, and also post intervention interviews with Swedish students, are still being analysed. During the ongoing analysis for the larger project, we have seen indications that the lessons seemingly worked well as an introduction to ethical and sociopolitical dimensions of societal applications of data science. For example, students displaying mature reasoning on how ethical and mathematical principles might interact in modelling, such as pointing out that models trained on data on human behavior may reflect discriminatory power relations in society, and if such models are used they can thus reproduce those discriminatory power relations. The activity seems to initiate students thinking about inter-relationship between data points in data sets. For instance, students already had a comprehension that big data sets are preferable to small data sets. But exercises made students aware that there can be a lot of junk data in authentic data sets, and that data quality is also an important aspects besides just data set size. Importantly, the activity engaged students in reflecting upon ethics. For instance, students expressed indignation about privacy being intruded upon. Such reactions open up a space for the teacher to lead a

discussion about intrusions of privacy under the guise of users having agreed to terms and conditions (which users do not fully understand the consequences of).

A potential contribution to the scientific knowledge of the field can therefore tentative be formulated as;

(1) Two standalone lessons can be mixed into mathematics courses and seemingly successfully provide an introduction to data science with ethics and societal perspectives foregrounded.
(2) Introductory activities that are unplugged and open ended can seemingly facilitate illumination of contingencies in mathematical modelling, which in turn could have a synergy with illuminating ethical aspects, i.e. focusing more on what *we ought to do*, rather than technical aspects of *how to achieve what we can* do.
(3) For the synergy in (2) to materialize, much seems to rely on the teacher. For example, to note differences in how students reason in the classroom, relate such reasoning to established data science methodology, and to utilize these differences in whole class discussions to point out contingences in modeling, and how different design decision during construction of a model may play out differently in relation to ethics.

However, these findings may not be fully argued for until the research results of the larger project is published, since those publications will contain a completed systematic review of students discourse during and after the lessons, i.e. a rigorous analysis of outcome of the lessons.

As a side note, activities have also been designed around ethical dilemmas in other authentic societal data science contexts, such as predictive policing (Andersson & Register, 2023), apps collecting health data, and face recognition technology. These tasks has been designed following similar principles as the Facebook data activity described above, and a framework for task design is gradually being developed (Andersson, Register & Stephan, 2024).

It is conjectured that continual use of classroom activates like these may reduce the risk of students themselves being exploited due to ignorance by making them more aware of possible issues. Furthermore, activities like this may perhaps provide a good starting point for the development of data science education (or data literacy) that encompasses not only data science technique but also societal awareness that goes beyond students self-interests and includes a sense of shared responsibility for social good.

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