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TEACHER EDUCATION ENCOUNTERS CLIMATE CHANGE AND CRITICAL MATHEMATICS EDUCATION

THINKING ABOUT CONTROVERSIES IN A STATISTICS COURSE

FORMAÇÃO DE PROFESSORES ENCONTRA MUDANÇAS CLIMÁTICAS E EDUCAÇÃO MATEMÁTICA CRÍTICA

Pensando sobre polêmicas em uma disciplina de estatística

FORMACIÓN DOCENTE SE CUMPLE CON EL CAMBIO CLIMÁTICO Y LA EDUCACIÓN EN MATEMÁTICAS CRÍTICAS

Pensar en la polémica en una materia de estadística

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ABSTRACT

In this study we discuss the complexity faced by a teacher when Critical Mathematics Education (CME) and climate change are being brought into a specific teaching setting that is part of a teacher education program a large university in Sweden. Taking CME and Active Network Theory into account along with the teacher's dilemmas, we here perform an inquiry that aims to map potential actants and their relationships, as they are core in a teacher's experience to plan and enact a statistics course that engages the theme of climate change through CME. For this inquiry, the teacher's log (or course diary notes) is analysed. The analysis locates instances where the teacher connects to different actants such as the climate change phenomenon, the curricula, the course plan, and student teachers. In some instances, these actants suggest ways of doing that contradict each other. In short, the analysis shows that since diverse arguments can be narrated, one might be left with the feeling of missing something in just following one. It is a rather vulnerable situation the teacher is in; risking being hold accountable for not dealing with the mathematical content that has good arguments for it to be dealt with, but, yet, knowing that taking this risk allows mathematics to enter the social.

Keywords: critical mathematics education. climate change. teacher education. active network theory.

RESUMO

Neste estudo discutimos a complexidade enfrentada por um professor quando a Educação Matemática Crítica (CME) e as alterações climáticas são trazidas para um ambiente de ensino específico que faz parte de um programa de formação de professores numa grande universidade na Suécia. Levando em conta a CME e a Teoria da Rede Ativa, juntamente com os dilemas do professor, realizamos aqui uma investigação que visa mapear potenciais actantes e suas relações, uma vez que eles são fundamentais na experiência de um professor para planejar e implementar um curso de estatística que envolva o tema do clima. mudança através do CME. Para esta investigação é analisado o diário de bordo do professor (ou notas do diário de curso). A análise localiza casos em que o professor se liga a diferentes actantes, tais como o fenómeno das alterações climáticas, os currículos, o plano do curso e os professores-alunos. Em alguns casos, esses actantes sugerem maneiras de fazer que se contradizem. Em suma, a análise mostra que, como diversos argumentos podem ser narrados, pode-se ficar com a sensação de perder alguma coisa apenas seguindo um. É uma situação bastante vulnerável em que o professor se encontra; arriscar ser responsabilizado por não tratar do conteúdo matemático que tem bons argumentos para ser tratado, mas, ainda assim, saber que correr esse risco permite que a matemática entre no social.

Palavras-chave: educação matemática crítica. mudanças climáticas. formação de professores. teoria de redes ativas.

RESUMEM

En este estudio discutimos la complejidad que enfrenta un docente cuando la Educación en Matemática Crítica (CME) y el cambio climático se llevan a un entorno de enseñanza específico que forma parte de un programa de formación docente en una gran universidad de Suecia. Teniendo en cuenta la CME y la teoría de redes activas junto con los dilemas de los docentes, aquí realizamos una investigación que tiene como objetivo mapear actantes potenciales y sus relaciones, ya que son fundamentales en la experiencia de un docente para planificar y ejecutar un curso de estadística que aborde el tema del clima. cambio a través de CME. Para esta indagación, se analiza el registro del profesor (o las notas del diario de curso). El análisis localiza instancias en las que el docente se conecta con diferentes actantes como el fenómeno del cambio climático, los planes de estudio, el plan de estudios y los futuros docentes. En algunos casos, estos actantes sugieren formas de actuar que se contradicen entre sí. En resumen, el análisis muestra que dado que se pueden narrar diversos argumentos, uno podría quedarse con la sensación de perder algo al seguir uno. Es una situación bastante vulnerable en la que se encuentra el docente; arriesgarse a ser responsabilizado por no abordar el contenido matemático que tiene buenos argumentos para ser tratado, pero, aún así, saber que correr ese riesgo permite que las matemáticas ingresen a lo social.

Palabras clave: educación matemática crítica. cambio climático. formación docente. teoría de redes activas.

Introduction

The purpose of this paper is to discuss the complexity that an educator in teacher education, with an interest in Critical Mathematics Education (CME) and climate change, must encounter when both social challenges are enacted in teaching. The teacher's way of working with climate change could be

conceptualized as working with a critical thematic context as described in Chronaki (2000), in the sense that it offers "opportunities to appreciate school mathematics cultural links and to reflect on its significance in real life situations" (Chronaki, 2000, p. 141). We are interested in what supports and what does not support the educator in this situation. CME (Skovsmose, 2013) has a focus on relations of power and resource inequalities between different social groups, which is highly relevant when student-teachers encounter statistics from a critical perspective (see the section on the context of the study). However, since our analytical focus more concerns understanding a CME inspired mathematics teacher's struggles in relation to the context, we turn to a framework which help us capture a network in which the teacher is a part: Active Network Theory (ANT) (Latour, 2005). ANT is used in this paper as a methodology and philosophy to shed light on the teacher's situation. ANT is a methodology since it provides a method of identifying the network, or in Latours own words, ANT is "a method to describe the deployment of associations like semiotics is a method to describe the generative path of any narration" (Latour, 2017, p. 9). There are several other possible theoretical frameworks that could have been used for our purpose, for instance Foucauldian discourse analysis, but we are intrigued by ANT, in that it includes an open starting point when analysing a social situation, in the sense of not taking a certain "social" for granted (Latour, 2005). Rather, ANT starts from the data, trying to avoid fixed notions and defined concepts of the "social". More about Latour and ANT will follow in the "theoretical considerations"-section.

A teacher is, as we see it, not alone in the teaching situation. This might become even more clear when the teacher is active in the field of CME and comes in line with Jablonka's definition of Mathematics education:

> Mathematics education is [...] concerned with the technologies of learning and teaching in institutionalized pedagogic settings. It [also] includes researching mathematics education in sites beyond the classroom (e.g., local communities and families, workplaces, policy making, the media, textbook production) and research activities that describe and theorize these practices, including research that is directed towards studying the social, economic and political conditions and consequences of those practices. (Jablonka et al., 2013, p. 43)

This definition presents a vast array of components, one could argue a network of practices of mathematics education, therefore thinking mathematics education with Bruno Latour might shed some new light. When Latour (2005) discusses how to start an investigation, he suggests that the identification of a dispute or, in his words, a controversy on what seems to be central for the whole arrangement of practice, can be a productive point of departure. For our exploration we suggest that controversies can be located when the teacher is faced with difficulty or a dilemma in choosing what to do, creating modes of hesitancy. There may be good arguments for choosing several paths, meaning there is a controversy between arguments that the teacher is faced with.

Controversies in mathematics education

Controversies are an important place from which the functioning and doing of science can be entered (Latour, 2005). While some views of scientific knowledge and practices would emphasize the production of facts and truth as the main result of the scientific endeavour, a relational form of inquiry allows to reveal that ways of doing appear not just because of their own value, but rather because there is a network of people, institutions and materialities that sustain them and their legitimacy as hegemonial narratives. This does not mean that the scientific facts of the external world are literally constructed of some other entities (Smelser; Baltes, 2001). Instead, the point is that science belief formation should be understood, mainly, in terms of social factors like rules, techniques, institutions, and negotiations. This could then be studied empirically and sociologically.

Examples of controversies in mathematics education may concern matters like which type of mathematical learning is more desirable; which type of teaching is fairer; or which can be more inclusive. In society, some controversies are more "important" than others, or some more "scientific" than others. These issues are more apparent for different people at different times. Controversies that have to do with knowledge, constantly emerge and are negotiated in mathematics education (see e.g., Boistrup & Valero,

in press). In this sense, the network of mathematics education can be seen as a field of cultural politics (Diaz, 2017; Valero, 2018). Having or keeping mathematics as a central subject in schools is one of these discussions. The controversy on the justifications for school mathematics does not only concern researchers in mathematics education (e.g., Niss, 1996), but also politicians, economists, educators, local authorities, and of course all the children who might like or dislike it. The above-mentioned controversy is crucial for mathematics education research and the many narratives that argue for its existence. The controversy forms the basis for the ways mathematics education is argued for, using ANT terms, the relationship between actants that constitutes mathematics education, and what knowledge that is seen as valuable (Boistrup & Valero, in press). Narratives about mathematics education as a field of research is connected to the arguments for more mathematically skilled people to secure a competent workforce. An assumption used is that it can be transferred to other fields such as the IT-industry or economics. This can be seen as one of the actants that influence mathematics education.

This study takes place in the field of CME. In this school of thought, Skovsmose brings in the concept of the formatting power of mathematics when he asserts that mathematics plays a role in formatting the world (Skovsmose, 2013). In other words, it creates a social and physical world after its own image. This power of mathematics is, of course, double edged. While many great achievements in science and technology were facilitated by mathematics, mathematics is also implicated in technologically caused catastrophes such as wars and mass destruction. (Atweh; Brady, 2009). Mathematics not only presents the world as it is, but it is also formatting how we act, it changes the way we think and how our physical reality is. Driven by core ideas of CME, mathematics has been conceived as a formatting power for articulating issues of climate change (Coles et al. 2013). Mathematics can change how the problem is perceived and formatted as predictable or solvable. When a statistics teacher is making certain choices of what data to look at, it also formats how we perceive the problem and its possible solutions. It is therefore of great importance for teachers and student-teachers to be aware of the possible consequences of these choices. It is with these thoughts in mind the teacher in this study set up the course.

Theoretical considerations

The study is inspired by Latour and his way of "reassembling the social" (Latour, 2005). To just refer to the social as the reason for why things are done the way they are, is not as exhaustive as one would like to think (Latour, 2005). So instead, he discards the concept of the social and tries to understand the relationships between what he calls actors or actants. The difference between actors and actants is that the term actant refers to an abstract structure, whereas the term actor is a concrete one, as described by Latour ". . .going from abstract structure -actants- to concrete ones -actors" (Latour, 2005, p. 8). The term actants is used to suggest that not only human have agency but non-humans as well. In our study we adopt the term actant throughout the investigation. The actant represents people and non-humans that have the possibility to produce a particular effect i.e., has agency (Smelser; Baltes, 2001). The relationships between actants that we as a collective iterate over time, is a way of thinking of how things are done. Furthermore, there are multiple connections between one actant and others, constituting a network of actants. Zooming into a particular actant would reveal yet another network. (Latour, 2005). "A network, in this second meaning of the word, is more like what you record through a Geiger counter that clicks every time a new element, invisible before, has been made visible to the inquirer." (Latour, 2011, p. 799). The metaphor of the network allows us to conceptualize a picture of the complexity that a teacher in teacher education moves into when engaging in teaching. The net also implies fragility, and the empty spaces between the arrays suggests possibilities. The notion of distance can be understood in how the net is constructed, i.e., the presence of bridges and hubs. Above all, what the network does to universality, any part of the network is accessible from anywhere in the network just as long as there are enough "antennas, relays, repeaters, and so on," to sustain the network. "In network, it's the work that is becoming foregrounded, and this is why some suggest using the word worknet instead" (Latour, 2011, p. 802). In other words, by using the concept of a net it is possible to localize where and through which other actants a certain actant is influenced. Rather than an existing stable entity, the network can better designate a mode of inquiry that learns to list, at the occasion of a trial, the unexpected beings necessary

for any entity to exist (Latour, 2011). Networks make visible the configuration in which things —human and non-human— are entangled and, in different ways, emerge as significant and powerful. Latour wants us to move away from accepted concepts that hinders deeper understanding for example "nature, society, or power, notions that before were able to expand mysteriously everywhere at no cost" (Latour, 2011, p. 802). In so doing, he writes, forces that affect people can be seen clearer. These ways of doing can be described as actants and their connections.

With these ideas in mind, we can now transform our question into narrower ones:

- Which are the actants in the network, when a mathematics teacher in teacher education is teaching in the field of CME, with an interest in climate change?
- Which are the connections and controversies between actants in this network?

To explore these questions, we performed an empirical investigation in which we followed actants and their relationships, as they are present in a teacher's log (or course diary notes).

Context of the study

This study is done at a teacher education program at a large university in Sweden. The course is in statistics and is compulsory for the student-teachers. The course typical has 30-40 students, studying to become teachers for pupils in the age group 10-12 years. The teacher in the course is inspired by CME and climate change. This is exemplified during the course by a short introduction into CME and activities based on CME are provided during the workshops. For example, the students discuss how different types of graphs could change the discourse around climate change (Coles et al., 2013). This is described below in excerpt 1.

> The graphs show the amount of carbon dioxide emitted from the countries Great Britain and India from the year 1880 until 2010. One of the graphs show the year-to-year emissions from both countries. The other graph shows a cumulative graph, where the previous years' emissions is added to the coming year's emission. As an example, reading the datapoint from year 2010 shows the total amount of emissions since 1880 for that country. The student-teachers then discuss how the different graphs illustrates the situation.

Excerpt 1: Excerpt from teacher's log on how the student teachers work with climate change.

The main author of this paper is also the teacher in the course in this study. In this sense this paper is an example of a self-study. Self-study is "a methodology for studying professional practice settings" (Pinnegar, 1998) while "teaching and research in self-study are iterative and responsive" (Laboskey, 2004). These advantages means that we (with author 2 and 3) as critical collaborators could enact the experience and findings from our first study into coming future studies.

Methodology

The main data used in this study comes from the teacher's log during the course. The log contains approximately 10 pages of the teacher's thoughts and reflections when preparing the course and during the enactment of the course. The course contained 5 lectures that were each follow by an activity. All the material that was used during the lectures and activities is also part of the data. An example here is the curriculum from the Swedish national agency for education and the statistics course syllabus.

This paper is inspired by Boistrup and Valero (in press), especially with regards to how the data was handled. One example is how all the text with at least one actant was transferred to a column in a worksheet. In the other columns we wrote actants, connections, controversies, type of controversy. We then identified all the actants and connections from the data. After this we identified and articulated the controversies. We have found that many of the controversies were in some way related to the teaching content, which then became our main point of focus. This means that when trying to map the network

i.e., the actants and the connections that constitute these controversies, we used the entry points concerning the content of the teaching. When doing so we aimed at better describing the controversies and what they are about. This is also in line with Skovsmose's and Cole and Barwell's thoughts mentioned above, about how the choice of content is pivotal for the teaching situation in CME. These actants, connections and controversies are listed in below section.'

Analysis and findings

Here we describe the findings. Following the analytical procedure described above, we first present the identified actants, followed by a presentation of different kinds of controversies, where, for each, some actants are involved.

Identifying actants

The main actant in this paper is the teacher at the course. Since we focused on controversies in relation to content matters, another given actant is teaching content. The teaching content can be described as content that the teacher will or has selected to illustrate CME in the context of climate change. Climate change is another given actant that can be described as an actant built up by other actants, which influences the teacher. Climate change is for instance conceptualized by the actant guiding documents from the UN, that is presented in the table below. We have zoomed in to one actant to find other actants, in line with Latour (2005). For example, we find graphs when zooming into teaching content. Here we present the remaining actants, apart from the given ones: teacher, teaching content and climate change.

Table 1: Description of actants with examples.

Actants	**Description**	**Example of quotes from the data**
Graphs	The graphs format how the lectures will be carried out and implies certain ways of thinking. Open new ways of thinking.	Example 1 above.
National curriculum for compulsory school	The national curriculum sets part of the format of the learning situation.	National curriculum: "The school is responsible for ensuring that each pupil on completing compulsory school can make use of critical thinking and independently formulate standpoints based on knowledge and ethical considerations," (Swedish National Agency for Education, 2018, p.12). Teacher's log: "I have added four slides that will connect to previous slides that concerns critical reflection mentioned in the national curriculum"

University course syllabus	The university course syllabus sets part of the format of the learning situation.	The university course syllabus: Student-teachers should be able to ”describe how pupils’ knowledge of concepts and ability to argue for and follow reasoning within statistics and probability theory can be improved”
Instrumental statistics	Suggests a more instrumental way of looking at mathematics and is the way the teacher has used statistics during previous time the course has been held.	Teacher’s log: “The first 5 instances of the course the film did not include the critical math perspective. The film then mainly contained statistics that relate to the more usual instrumental part of statistics.”
Student-teachers	Comes with expectations to the course.	Teacher’s log: “student-teacher asks which of the graphs are the best one”.
Guiding documents	Guiding documents influence part of the teaching situation.	For example, guiding documents from the United Nations (UN).
United Nations (UN)	UN comes with guiding documents that the teacher relates to.	United Nations: “recognizing also the role of education for sustainable development in promoting and enhancing public awareness of the eradication of poverty, of sustainable consumption and production, of combating climate change.”
Teaching traditions	“Every tradition has its shortcomings and strengths.” (Öhman & Östman, 2019, p.76).	Teacher’s log: “One student talked about how he thinks teachers has a responsibility to be normative or an activist, that is to fight climate change”

Controversies between actants

Our focus area is controversies that are related to the actant teaching content, as mentioned above. Below we follow these controversies that have been thematically grouped, meaning there are several instances of controversies from the teacher’s log that have been mapped to a specific theme. The controversies are illustrated by quotes from the teacher’s log and a general description of the theme. In other words, it is the teacher’s experienced controversies concerning teaching content.

Controversies concerning the curriculum

Actants involved: the teacher, teaching content, climate change and the curriculum. The controversy can be traced back to the Swedish curriculum for compulsory school.

The Swedish curriculum for the compulsory school states: "It is also necessary for pupils to develop their ability to critically review information, facts and relationships, and to be aware of the consequences of different alternatives." (Swedish National Agency for Education, 2018, p. 7). This critical perspective is also mentioned in a few other places in the beginning of the curriculum. However, this is not followed up in the instrumental part of the curriculum (Andersson et al., 2023). Instances from the data that has this characteristic are for example when the teacher expresses (excerpt 2):

> Thinking about if I have made the right balance in how much of this material I have brought in, is it too much or too little? From previous experience when the course was held, many students have been insecure about mathematics and if I now add more material will they maybe feel even more insecure.

Excerpt 2: Excerpt from Teacher's log on the balance in relation to the mathematical content.

In excerpt 2, we see how the teacher hesitates between choosing content which relates to the more instrumental part of mathematics, and content which would fulfill the requirement about critical perspective and discussions from the national curriculum. This is addressed in a slight different way in excerpt 3.

> I am thinking about how many students are willing to do this extra work on reading this quite advanced text, will they put in that extra time and effort on something that is not needed to get a pass on the course?

Excerpt 3: Excerpt from teacher's log on students' willingness to read advanced text.

From excerpt 3 we can see the same type of hesitation by the teacher in bringing in content in line with the critical perspective, which might have to do with instrumental mathematics being more emphasised in the curriculum.

Controversies concerning other guiding documents

Actants involved: the teacher, teaching content, climate change, curriculum, and other guiding documents for instance from UN.

This controversy has to do with the teacher's choice of content suggested by other guiding documents compared to the national curriculum but also the general public's understanding and valuation of what is the most important part of climate change. These guiding documents does not always emphasis the same issues concerning climate change and is presented in different way.

It is also about the valuation of content from different sources. What sources are the most trustworthy and how the teacher should evaluate this. This controversy touches upon the political world and demands that the teacher has a good general understanding of the political landscape concerning climate change. The national curriculum provides little support to the teacher with its very general formulations concerning critical thinking and climate change.

Controversies concerning students' expectations

Actants involved: teacher, teaching content, climate change, instrumental statistics, and student-teachers.

The controversy is between what the students expect when they come to a lesson in statistics and what the experience is for the student-teachers at a CME inspired statistics education. In the teacher's log, the controversy can be found in statements like "students ask which of the graphs are the best one", suggesting that there is one right answer, and that the teacher notes that the students are working more on the instrumental part of the graphs. From this we can notice expectations from the students on what they expect they should work, ask and talk about.

Controversies concerning teaching content

Actants involved: the teacher, teaching content, and climate change.

The controversy is about the teacher's awareness of that in bringing in a certain type of content, the teacher is in fact formatting the discourse around climate change (Coles et al., 2013). This could be found in statements from the teacher log like in excerpt 4 and excerpt 5.

> "[…] and it strikes me that when I am doing these choices, I am also deciding what is most important concerning climate change."

Excerpt 4: Excerpt from teacher log about teacher choices.

> Maybe show the temperature based on countries and then a picture of the temperature globally, where one could see that the weather does not care about country limits.".

Excerpt 5: Excerpt from teacher log about climate change.

In excerpt 4 and 5 we can see the teacher is hesitating in making the right choices when trying to present climate change.

Controversies between teaching traditions in relation to teaching content

Actants involved: teacher, teaching content, climate change and teaching traditions.

The controversy has to do with the teachers own ethical struggle on whether following one's own conviction, or not. Should the teacher be normative in a pressing matters like climate change or use a more democratic approach of allowing all type of discussions, even climate change denial. In the teachers log we find a statement related to this type of controversy (excerpt 6).

> One student talked about how he thinks teachers has a responsibility to be normative or an activist, that is to fight climate change".

Excerpt 6: Excerpt from teacher log about student reflections.

The approach displayed in excerpt 6 is one approach which (Öhman; Östman, 2019) calls the the normative tradition. "Every tradition has its shortcomings and strengths." (Öhman; Östman, 2019, p. 76). One shortcoming of the normative tradition is that it is

> not in line with democratic principles. A democracy allows each individual, based on knowledge, experience and values, to form their own understanding and develop a line of reasoning that supports their convictions. The normative tradition runs the risk of turning education into a political tool to create a specific predetermined society. (Öhman; Östman, 2019, p. 78).

On the other hand, in pressing matter like climate change the normative tradition has its strengths as well, for instance, by sidestepping time consuming democratic discussions.

Conclusions

A teacher in mathematics education is situated in a network of other actants which in many ways stages what the teacher can and cannot do, the network provides constrains and affordances. We aimed to unfold a discussion of that complexity. Our choice of using ANT is one way of investigating this and we would argue, also, part of that complexity. Our investigation suggests that the complexity increases when a teacher moves into teaching by encountering Critical Mathematics Education (CME) and climate change. The complexity increases in the sense that new actants are introduced in the network, some of these new actants became the source of dilemmas that the teacher is experiencing. We find instances where the teacher connects to different actants for instance climate change, the curriculum, the course

plan, and the student-teachers. In some instances, these actants suggest ways of doing that contradict each other. That leads to difficult decisions that leads to a hesitation by the teacher. There are different narratives about what are the most important mathematics and in some sense the teacher makes a choice of which narrative to follow. The hesitation might be traced back to the arguments for each narrative. There could be good arguments for several narratives which could lead to a feeling of missing something in just following one. It is a rather vulnerable situation the teacher is in; risking being accused of not dealing with the stuff that has good arguments to be dealt with.

One way of dealing with this could be to invite the discussion in the classroom, especially for student-teachers since they will eventually be faced with the same situation in their practice. This could heighten the awareness among student-teachers and the teacher about all the actants that are influencing the teaching situation. Being aware of the complexity of the situation could help the teacher and student-teachers being able to argue for their choices, actively aware in relation to which narrative they make their choices and be aware that all narratives could not possibly be covered.

In *Controversies between other guiding documents regarding climate change* we have realized, when going through the teachers log how much work it takes for the teacher to present this information in a professional way. Guiding documents from UN and other institutions should be reviewed and a good general understanding of the political landscape around climate change is needed to be able to invite and lead student-teachers discussions concerning the social challenges of climate change. The investigation also suggests that sufficient time is needed to make sure that student-teachers have a good mathematical understanding of the content before any discussion can take place otherwise there is a risk of having more of an instrumental type of discussions without getting into the critical thinking about the content.

To conclude, we would also like to add that not only controversies are present in the teacher's log, but the teacher also experiences a great joy in working with CME. This could for instance be found in statements like "my reflection is that this touches on something important and something bigger than statistics it self". It is also expressed that, despite controversies, the teacher feels more energized when the CME becomes part of the course and as he proclaims: "critical mathematics has a soul".

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