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EXPERIENCING CRITICAL MATHEMATICS EDUCATION

CHANGES IN STUDENTS' PERSPECTIVES ON THE RELEVANCE OF MATHEMATICS1

EXPERIMENTANDO LA EDUCACIÓN MATEMÁTICA CRÍTICA

Cambios en las perspectivas de los estudiantes sobre la relevancia de las matemáticas

EXPERIMENTANDO A EDUCAÇÃO MATEMÁTICA CRÍTICA

Mudanças nas perspectivas dos alunos sobre a relevância da matemática

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ABSTRACT

When students ponder why they consider it relevant to learn math it becomes apparent that their attributions of relevance do not meet what educational policies state as goals. While they generally consider the subject to be important, their explanations why they do so are limited to only elementary mathematical skills needed in everyday life or unspecified skills for later work life, rarely connecting them to broader societal topics. Integrating Critical Mathematics Education (CME) tasks into math lessons might be a chance to let attributions of relevance evolve further. This contribution shows in how far the students' perspectives on the relevance of math changed after they experienced several CME units. 16 students from three different schools have participated in two rounds of interviews where they have been asked about their image of math and math learning and if and what they consider relevant. Within the second round of interviews, after they experienced several CME units, additional questions about their experiences in these lessons have been added. The analysis shows that students' general attribution of relevance did not change considerably. However, effects could be identified in their reflections about the CME units. Students talked about how these units let them experience a connection between math and societal topics that leads to a more personal and direct relevance of math for their lives. However, their understanding of what counts as doing math might hinder them to easily transfer their experiences within these units to their general attributions of relevance of math. If teachers regularly include CME tasks into their math lessons and make reflections on what mathematical activities have been applied to make sense of them an integral part of instruction, CME seems to offer the opportunity for students to broaden their conceptions of math and experience connections between math and societal topics more clearly.

Keywords: critical mathematics education. relevance. students' perspectives.

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RESUMEN

Cuando los estudiantes reflexionan sobre por qué consideran relevante el aprendizaje de las matemáticas, resulta evidente que sus atribuciones de relevancia no se ajustan a lo que las políticas educativas establecen como objetivos. Aunque en general consideran que la asignatura es importante, sus explicaciones de por qué lo hacen se limitan únicamente a las competencias matemáticas elementales necesarias en la vida cotidiana o a competencias no especificadas para la vida laboral posterior, y rara vez las relacionan con cuestiones sociales más amplias. La integración de tareas de Educación Matemática Crítica (EMC) en las clases de matemáticas podría ser una oportunidad para que las atribuciones de relevancia evolucionen aún más. Esta contribución muestra hasta qué punto cambiaron las perspectivas de los estudiantes sobre la relevancia de las matemáticas tras experimentar varias unidades de EMC. Dieciséis alumnos de tres centros diferentes participaron en dos rondas de entrevistas en las que se les preguntó por su imagen de las matemáticas y del aprendizaje de las mismas, si las consideraban relevantes y qué hacían. En la segunda ronda de entrevistas, después de que experimentaran varias unidades de EMC, se han añadido preguntas adicionales sobre sus experiencias en estas lecciones. El análisis muestra que la atribución global de relevancia por parte de los alumnos no cambió considerablemente. Sin embargo, se pudieron identificar efectos en sus reflexiones sobre las unidades EMC. Los alumnos hablaron de cómo estas unidades les permiten experimentar una conexión entre las matemáticas y los problemas de la sociedad que conduce a una relevancia más personal y directa de las matemáticas en sus vidas. Sin embargo, su comprensión de lo que se considera hacer matemáticas podría impedirles transferir fácilmente sus experiencias dentro de estas unidades a sus atribuciones generales de relevancia de las matemáticas. Si los profesores incluyen regularmente tareas de EMC en sus clases de matemáticas y hacen de la reflexión sobre qué actividades matemáticas se han aplicado para darles sentido una parte integral de la enseñanza, la EMC parece ofrecer a los alumnos la oportunidad de ampliar sus concepciones de las matemáticas y experimentar más claramente las conexiones entre las matemáticas y los problemas de la sociedad.

Palabras clave: educación matemática crítica. relevancia. perspectivas de los estudiantes.

RESUMO

Quando os alunos ponderam por que consideram relevante aprender matemática, fica evidente que suas atribuições de relevância não atendem às metas estabelecidas pelas políticas educacionais. Embora, em geral, considerem a disciplina importante, suas explicações para isso se limitam apenas a habilidades matemáticas elementares necessárias na vida cotidiana ou a habilidades não especificadas para a vida profissional posterior, raramente relacionando-as a tópicos sociais mais amplos. A integração de tarefas de Educação Matemática Crítica (EMC) nas aulas de matemática pode ser uma chance de permitir que as atribuições de relevância evoluam ainda mais. Esta contribuição mostra até que ponto as perspectivas dos alunos sobre a relevância da matemática mudaram depois que eles passaram por várias unidades de EMC. 16 alunos de três escolas diferentes participaram de duas rodadas de entrevistas em que foram questionados sobre a imagem que tinham da matemática e do aprendizado de matemática e se e o que consideravam relevante. Na segunda rodada de entrevistas, depois de terem experimentado várias unidades de EMC, foram acrescentadas perguntas adicionais sobre suas experiências nessas aulas. A análise mostra que a atribuição geral de relevância dos alunos não mudou consideravelmente. Entretanto, foi possível identificar efeitos em suas reflexões sobre as unidades de EMC. Os alunos falaram sobre como essas unidades permitem que eles vivenciem uma conexão entre a matemática e os tópicos sociais, o que leva a uma relevância mais pessoal e direta da matemática para suas vidas. Entretanto, a compreensão que eles têm do que é considerado fazer matemática pode impedi-los de transferir facilmente suas experiências nessas unidades

para suas atribuições gerais de relevância da matemática. Se os professores incluírem regularmente tarefas de EMC em suas aulas de matemática e fizerem reflexões sobre quais atividades matemáticas foram aplicadas para dar sentido a elas como parte integrante da instrução, a EMC parece oferecer a oportunidade para que os alunos ampliem suas concepções de matemática e experimentem as conexões entre a matemática e os tópicos sociais de forma mais clara.

Palavras-chave: educação matemática crítica. relevância. perspectivas dos alunos.

Introdution

How useful and relevant the content of a subject appears to students for their present and future lives is often not only decisive for how much students enjoy learning new content (e.g., Canning & Harackiewicz, 2015), but ultimately also contributes to a legitimation of the school subject itself. What is considered socially or politically relevant is usually reflected in the formulated goals of education in general and for each subject in particular in educational policy, including the curricula. In the case of mathematics education, it becomes clear that students are meant to learn more than mathematical facts and procedures, and their understanding of mathematics should go beyond one of immediate applicability (BMBWF, 2022). Also academic discourses revolve around the question of relevance and purpose of a specific subject. In German-speaking countries, discourses around that question traditionally depart from the idea of "general education" (*Allgemeinbildung*).

Influential contributions in that regard were brought up, for example, by Heymann (2003), who considered it important, among other things, that students should "attain an overall perspective [on the world around them], to be able to make sense of the phenomena they encounter and understand the relationships among them, to have a working knowledge of the world beyond the horizon of their own limited experience" (p. 35). Mathematics education should, therefore, not only enable students to apply what is learned directly in their life but also to understand social contexts that go beyond the individual dimension. Similarly, Fischer (2012) emphasized reflection, which involves interpreting knowledge and operations regarding the requirements of a specific situation, placing them in larger contexts, and finally evaluating them. This should ultimately also help to dismantle the subjects' boundaries, in other words, contribute to an examination of the extent to which central ideas may be relevant beyond the subject itself (Heymann, 2003).

When looking at what actually reaches the students, it becomes apparent that these goals, like many desirable ideas formulated in mathematics education research, can often only be considered an illusion. Studies show that students generally consider mathematics a very important subject, regardless of whether they like it or not (Kislenko et al., 2007). If they were asked more closely why they feel mathematics is important, their attributions of relevance usually remain unfounded, and students quickly falter with their explanations. In most cases, these explanations are limited to elementary mathematical skills needed in everyday life, like going shopping or building a house, or to unspecified skills that they might use later in their professional life (Kollosche, 2017; Maaß, 2013; Gebremichael et al., 2011). Moreover, it seems that if students see some relevance for their lives, it only touches the individual level but rarely connects to broader social topics.

Similar results were found in the pre-interviews with students in the research project discussed in this paper. This confirms that it is arguably very difficult to extend students' relevance attributions in the current 'traditional' form of teaching mathematics beyond those frequently stated by the students. However, these definitely fall short if we want to work towards the above-mentioned educational goals. As Kollosche (2017) concluded, this would probably require a "completely different style of teaching mathematics, a style which allows the students to experience and reflect on the educational goals envisaged" (p. 641). One approach to teaching mathematics that might evolve students' attributions of relevance is the one of Critical Mathematics Education (CME). Within CME, socio-political and critical perspectives are included in mathematics lessons that should foster a broader understanding of the social,

cultural, and political dimensions of mathematics in society (Skovsmose, 1994). This includes a (critical) engagement with mathematics that goes beyond memorizing mathematical facts and procedures (which are also important), but also refers to mathematics as a tool for examining and transforming the world.

This might create possibilities for students to experience mathematics in different ways and connected to social, cultural or political issues and might, therefore, evolve their attributions of relevance. This paper investigates how students experienced CME lessons, focusing on effects that show up in the students' attributions of relevance. This leads to the following research question: *How do students' perceptions of the usefulness and relevance of mathematics evolve when a CME approach is used?*

Students' perceptions of the relevance of mathematics

Research on students' perspectives on teaching and learning mathematics has increased in recent decades. Contributions vary in their focus and might use various theoretical concepts like conceptions/perceptions, experiences, or beliefs and attitudes. Many of the studies on students' beliefs also deal with the topic of importance and usefulness or relevance of mathematics. Most of these are quantitative in nature, using closed questionnaires to survey students' perceptions. While some studies report that students only learn math for the use in school in order to pass exams (Onion, 2004), others show that mathematics is generally considered and ranked important (Agüero-Calvo et al., 2017). However, it often remains open what lies behind the students' ideas about the importance of mathematics or what influence teachers or teaching might have.

Maaß and Ege (2007) and Kollosche (2017) showed in their qualitative contributions that students seem convinced of the relevance of mathematics. Still, their relevance attributions often stayed vague and at a superficial level. They mainly named needing mathematics for dealing with money or for their later profession. Relevance was often attributed to an unspecified later point in life or indirectly as a prerequisite for future studies or other subjects (Gebremichael et al., 2011). Kollosche (2017) summarized that the students' explanations often stop "at that connection between relevance and profession, the relevance still lies in an inapproachable distance and does not connect to anything the students are doing in the classroom" (p. 639). Maaß and Ege (2007) concluded that most students do not have any insight into the importance of mathematics for society. Some seem to experience mathematics primarily as a self-referential system or only as an academic exercise without any connection to societal issues. Gebremichael et al. (2011) reported similar experiences and stated that some students even started to challenge teachers when they wanted to include real-life problems in mathematics teaching.

Critical mathematics education

Definitions of CME differ among those who practice or write about it, which is why contributions often vary in their focus. Andersson and Barwell (2021) characterized it as a form of mathematics education that is "driven by urgent, complex questions; is interdisciplinary; is politically active and engaged; is democratic; involves critique; and is reflexive and self-aware" (p. 3). They summed up three broad CME traditions: a Freirean, which highlights the importance of raising learners' consciousness as they are experts and actors for change in their own (social) environment, a Foucauldian, which focuses on mathematics in relation to discourses, and the Nordic School as driven forward by Scandinavian contributions, that emphasize the analysis and also critique of the role mathematics plays in their lives and in society.

Empirical studies within the field rarely focus on students' reactions to the implementation of a CME approach explicitly. Studies that included student feedback reported of an increased student engagement (of most students) as the students could see a personal connection to the topics worked on in class (e.g., Brantlinger, 2013; Gutstein, 2006; Wright, 2020). The shifted way of doing mathematics also caused a shift in the way students perceived mathematics. Some articulated that they learned how powerful math can be as it helps to explain and justify things (e.g., Brown, 2009; Gutstein, 2006; Wright, 2020).

However, students did not always react in ways intended by the teachers. Especially at the beginning of changing the teaching approach, students did not think about more critical perspectives without the teacher's help (Brantlinger, 2013) or interpreted mathematical results in ways that reinforced rather than challenged problematic views and stereotypes (Esmonde, 2014; Kokka, 2020). This indicates that using mathematics to understand societal issues and thereby developing mathematical consciousness is not a straightforward process and needs practice, just as learning inner-mathematical content does.

Research context and methods

The data for answering the research question were collected as part of a larger research project, in which a teacher training program with nine mathematics teachers on the concept of CME took place. I designed and carried out the workshops between October 2021 and May 2022. During this period, the teachers and I met approximately once a month (including a break due to COVID restrictions). We collectively elaborated on the concept of CME and possible practical realizations for their math classes. Thereby, we did not focus explicitly on one of the concepts mentioned above. The main goal was to collaboratively work on tasks they could bring into their classroom where students could experience how mathematics might be used to identify, interpret, evaluate and critique mathematics embedded in social, scientific, economic, or political systems. Most teachers (7) were middle school teachers from the school where the meetings took place. A higher vocational teacher and a high school teacher who were interested in the content of the workshops also participated. Student data were collected from three different classrooms taught by three teachers. Two of them also agreed to classroom observations, which were videotaped. All students of the three classes were asked if they wanted to take part in the study and do two interviews. Teachers were asked to select high-achieving, low-achieving, and average students from the group of voluntarily participating students and to also consider students who like mathematics as well as some that might not. Assuming that the teachers know their students well, this selection method was chosen to capture as many different student views as possible. A total of 16 students participated in the interviews. As the teachers could freely decide in which class they specifically wanted to apply a CME approach, students differed in age and, therefore, in their experience with mathematical content. Three students attended a higher vocational school (9^{th} grade), seven a grammar school (8^{th} grade), and six a middle school (7^{th} grade).

The first round of one-on-one semi-structured interviews was carried out at the beginning of the school year. Questions revolved around what image students have of mathematics, how they experience math lessons, how they think they best learn math, and what they consider relevant. After we worked on possible practical implementations over the school year, the teachers were free to choose tasks they thought would fit best in their classrooms. While some took exactly the tasks we discussed in the course, others modified some parts to make them a better fit, and again others designed new tasks themselves. Designed lessons applied in classrooms of the interviewed students dealt with topics like wealth distribution, taxes, and cost of living in Austria, or water consumption of food.

Tasks dealing with injustices in the distribution of wealth on a national or international level cover an important societal issue and seem to be a popular example for bringing critical aspects into the mathematics classroom (e.g., Esmonde, 2014; Gutstein, 2003; Staples, 2005; Wright, 2016). Similarly, engaging in a task about the tax system, that is based on mathematical models, provides an opportunity to reflect on how the use of mathematics creates realities. Students can think critically about the extent to which changes in the system can favor or disadvantage different groups of people. The task about water consumption of food aimed at letting students critically reflect on their consumer behavior by using math to question myth about environmental impacts of food production. It initiated reflections about how their decisions can have an impact on the environment and also about individual versus political responsibilities in regard to environmental issues.

The second round of interviews with the students took place after the teachers integrated these CME aspects into several lessons (every teacher spent at least 6 hours on these units before I interviewed the students). Again, questions about the students' image of mathematics and its relevance and usefulness

for their lives were discussed. Compared to the first round of interviews, a section that specifically focused on how they experienced CME lessons was added to the conversations. Interviews were carried out and transcribed in German and I translated important parts into English.

For the analysis, I followed a qualitative thematic analysis method (Braun & Clarke, 2006). I started by reading and re-reading the transcripts of the first round of interviews and coding the data without trying to fit the codes into any specific category that other literature has brought up. After coding the data with the help of MAXQDA I grouped them into broader themes and possible sub-themes. One of the broad themes that came up was "relevance of mathematics" This includes all statements of students that deal with relevance attributions to mathematics. This comprises answers to the specific question what mathematical content they consider relevant and why, but also other parts of the interviews where the students brought up the topic themselves.[2] The process was repeated for the second round of interviews. This time I focused especially on feedback and reflections on the CME units, where students elaborated on how they worked, what they liked or did not like, and what they felt was different compared to "normal" math classes. In order to specifically identify what might have changed in their attributions of relevance of math, I compared statements dealing with this topic (in pre- and post-interviews) of every individual student in a third round of analysis. Additionally, I wrote memos during the analysis to catch thoughts that came up while reading that might help to make even better sense of the data.

Results

Students' answers in the first round of interviews yielded results similar to those reported in the literature and did not substantially differ between different age groups and school types.

Analysis showed that the aspect of usefulness seems to be central for many students, even to the extent that they name usefulness an essential feature of mathematics. When asked more closely why they consider it important, they often struggled to explain their thoughts in more detail. Their attributions of relevance of mathematics at this point rarely went beyond general and superficial understandings, primarily referring to an unspecified, later point in time. Most of them mentioned only elementary mathematical skills they might need for every-day life, like going shopping or building a house later. The argument that they consider it essential to learn math since they will need it later in life came up again and again. Besides these attributions, nearly all students referred to the importance of mathematics for professional life. Again, most comments were very general in nature and pointed to an unknown point in the future. When asked to elaborate more on why it is important to have mathematical knowledge for professional life, students seemed to struggle to develop more sustained statements. It was noticeable that students' references to the relevance of mathematics were mainly formulated as a general rather than an individual attribution. This could be noticed in the students' frequent use of indefinite instead of definite pronouns or their attenuation of arguments by including words like "generally", "in principle", or "everybody". Interestingly, some students even seemed to be aware that they could not justify their perceptions but still insisted on the (very general) importance of the subject. At this point, students did not see any connection between math and societal topics or mentioned math being important for anything other than counting or calculating.

When comparing the answers to the explicit question about the relevance of mathematics from the first round of interviews with those from the second round of interviews after the students had experienced CME units, no fundamental changes in attributions could be identified. Most students stuck to the general attributions of relevance for later life, especially for work life, without being able to justify their statements. Many students mentioned the same examples as in the first conversation or added some very basic other explanations.

However, a closer analysis of students' reflections on the CME units (the focus of several later questions in the second round of interviews) showed that effects on their relevance attributions (at least when

[2] Includes statements like: I find math important because…, I consider math interesting cause I need it for…

talking about these lessons and the covered content there) were indeed noticeable. When students talked about the CME lessons, they did not only refer to how they experienced these, how they worked, and what they were able to take with them but often brought up the point that these lessons helped them understand essential issues going on outside of school through the use of mathematics. Many expressed how important they considered the (societal) content learned in these lessons, as Lucy's statement after learning about water consumption of different kinds of food in the CME units shows:

> Lucy: I think these lessons were pretty interesting. Because the topic of water consumption is something that affects us all a lot and I think it's pretty cool when you then.... when something so important is connected to math […] and I also learned a lot of things that I didn't know at all before.

Overall, the analysis of students' reflections on the CME units revealed that their attributions of relevance seemed to evolve, particularly in relation to the point of reference and connection between mathematics and social issues. In contrast to the very general explanations and the reference to later usefulness, the relevance attributions in their reflections of the CME lessons referred to a more concrete and immediate use. Students mentioned that because of these lessons, they understood issues that were (just) happening around them. Many saw a direct relevance for their lives by including these topics in mathematics classes and emphasized how important they consider seeing connections but also how seldom that happens in mathematics. When asked about what was different in these CME lessons, Peter, an 8th grader, explained:

> Peter: Um... Yeah, definitely with like... looking at situations that you have in real life. […] We don't do that often in math and that's actually it. So, that you look at something that is also like that in real life. We hadn't done that so often.

In addition to a seemingly more immediate relevance, there was also a noticeable trend in considering learned content important for themselves instead of only attributing very general importance. For some students, the content learned in these lessons appeared to directly impact their lives outside of school as they seemed to rethink or even adapt their behavior. Many mentioned that they talked with their parents about the lessons. Lucy explained how learning that avocados do need more water than other vegetables or fruits but much less than meat impacted the consumer habits in her family:

> Lucy: I also told my mother about it. And she said, then we'll just um.... we will be more careful what we buy now. And we usually ate five avocados a week or so. Now I haven't seen any avocados in my kitchen for a long time.

Similarly, others explained that they are more aware of what is happening around them and that they never questioned facts they had heard about the topic before, like Katrin's' response shows:

> Katrin: I've often heard that avocados are bad for the environment, but I never questioned why actually. So, I was surprised that meat actually needs so much water.

Now that they could better understand what is behind these facts, they felt better prepared to talk about it and were happy to contribute to discussions they experienced outside of school. Katrin explained that in conversations with her cousin, who is vegan, "it was kind of... yes, was exciting to actually know something [about the topic of water consumption of food] now". She felt much more confident within these conversations to also point out facts that contradict the criticism that vegans often hear (e.g., "Vegans want to do something good for the environment but at the same time consume vegetables that need a lot of water"). Engaging with the topic led to her interest in similar issues, and she conducted further research outside of class.

> Katrin: So I then... I researched, because I was really interested in it, how much water is available on earth, how much of it is salt water, fresh water. And how much is really usable fresh water, as drinking water. I found that really exciting. Maybe we could have looked at all that together [in class].

Addressing such topics in class seemed to motivate her to search for other data that connects to it. It becomes clear that she obviously sees a connection between what she has learned in school and real-life

issues and would like to deepen this by bringing new information and statistics into the classroom to make sense of it together.

Eva, a higher vocational student, first seemed surprised that such societal topics have something to do with mathematics. However, she seemed to have changed her mind after the units since she highlighted the importance for their lives outside of school when covering such topics in mathematics class.

> Eva: That we have [touched the topic of] wealth distribution, which I thought has nothing to do with mathematics at first, but we did it anyway, because that is also something very important for us outside [of school]. […] Wealth distribution, with money, we simply learn about that already in the first grade [9th grade, but first year in that school], how that's distributed, how all this generally works in Austria and so on...

In a similar vein, Victoria expressed her surprise at learning about taxes:

> Victoria: I was wondering... You have to pay wage tax? Because there was a task about wages... different things that I didn't know. [...] I was like [wondering]... What? You have to pay a wage tax? For getting money? So, there was a real question mark in all our heads. It was quite interesting learning about that.

These examples indicate that the students appreciated learning about real-world issues in mathematics. While some were not sure what they learned mathematically in these lessons (Steflitsch & Deweis-Weidlinger, in press), others explicitly articulated that they realized that through the use of math they could better understand, reflect and evaluate certain (societal) issues and that mathematics can help make things clearer.

Overall, the students' reflections indicate that although they were not able to transfer their experiences to their general explanations about the relevance of mathematics (yet?), working on CME tasks might create the conditions for a later transfer.

Discussion and implications

The students' discourses on the relevance of mathematics did not seem to develop considerably over the school year and after these CME units. Explicit questions about the relevance of math were answered in almost identical terms and with very similar examples in both interviews. This is rather unsatisfactory for two reasons. First, the relevance attributions do not seem to evolve any further after a certain grade level, regardless of what new mathematical content is being covered in the following years. Only sporadically, further developments beyond the generalized relevance attribution for elementary mathematical skills that could directly be applied and will be needed in the future could be observed. Second, using a CME approach does not seem to contribute significantly to an (immediate) enhancement of the already very entrenched perceptions. Or at least students did not transfer experiences made in these lessons to their general relevance attributions, irrespective of grade level or topic covered.

That students obviously struggle to transfer these expressions of importance to their general attributions of relevance might have several reasons. First, it has been shown that changing beliefs is generally challenging and needs time (e.g., Kaiser & Maaß, 2006). Another major reason might be the students' general perception of (school) mathematics. If they (and maybe also the teachers) only think of doing math when actually doing calculations they might not value other mathematical activities that go beyond, like representation, interpretation, argumentation, or justification. CME tasks often emphasize these other competencies and might sometimes include only very basic calculations. Therefore, students might struggle to see which mathematical competencies are applied to fully make sense of societal topics even though they experienced it within the CME units. It seemed as if they only valued calculations as a truly mathematical activity but did not consider doing math when they discussed different (mathematical) approaches to find a solution, analyzed graphs or data, drew graphs themselves, compared and critiqued different solutions (Steflitsch & Deweis-Weidlinger, in press). Also other empirical studies showed that

students' beliefs about math are mainly scheme-oriented and that they seem to become accustomed to doing mathematics without thinking much about it (Kloosterman, 2002).

Even though none of the students articulated that CME tasks did not fit into math class or that they did not understand why they included such topics into math class, which was often the case in prior studies (e.g., Brantlinger, 2013; Gutstein, 2006), it seemed, that their understanding of doing mathematics somehow hindered them from seeing a connection between mathematics and societal topics. This claim is supported by the fact that students could not really think of other issues that might be suitable or interesting for them to deal with in mathematics class. When explicitly asked for possible other topics, they either expressed that they could not think of any other or the topics were very similar to the ones already covered in prior CME units. Often, they weren't sure if topics they are interested in would fit into math and might, therefore, even see the need for creating a new subject where they cover issues that are important for their lives. This rigid separation of different subjects could be one reason why the general relevance attributions have not noticeably evolved, as students do not (yet) seem to perceive the inclusion of social issues as a 'normal' part of mathematics education. In general, students apparently had little insight into the role of mathematics in society and could not independently establish or see connections to social issues. If this is to be one goal of mathematics education, then we need to give them the opportunity to experience these connections within mathematics classes.

What gives cause for hope is that tendencies for possible further development can be identified in the students' reflections on CME units. As these show, students valued a critical engagement with societal topics in the math classroom, and they reported seeing a personal and direct relevance for themselves and for a participation in social discourses. This indicates that attributions might evolve in a direction that is also more in line with learning objectives formulated within educational policy (e.g., working on social issues, critical thinking).

To strengthen the transfer of separate relevance attributions for certain units to students' general ones, it seems essential to include these approaches regularly as a normal part of teaching mathematics. Students need time to get used to a different kind of teaching and a different kind of mathematical tasks and problems. This is also indicated by Gutstein (2006) who concluded that "although [he] had taught this class for a year at the time of this project, students had apparently not internalized using mathematics to analyze social realities." (p. 47). Kaiser and Maaß (2006) reported that first changes in students' views about modeling tasks with social contexts were noticeable after 15 months, even in students that first showed strong resistance.

The results indicate that for a better understanding of the (long-term) effects and impacts of CME at the student level, it is not sufficient to focus on the students' direct feedback and reflections about CME teaching or specific units or projects. Closer attention must also be paid to how the students' general perceptions of mathematics change. Longer-term studies focusing on the effects of CME teaching on students would provide information on the extent to which changes are noticeable and whether formulated goals are (sustainably) reached.

Based on the present findings, teachers might want to make reflections about the relevance of mathematics and connections to societal topics an inclusive part of their teaching as this might help to make students even more aware of that. Especially reflecting on the different mathematical activities that might have been applied to make sense of the discussed issues seems essential to not solely value doing calculations as doing mathematics. This also offers the opportunity to critically reflect on the role that mathematics plays in these contexts. Including societal topics into math classes regularly and an explicit focus on the different mathematical activities applied might broaden the students' conceptions of mathematics and their perception of where mathematics might be helpful to understand things better but also where the boundaries of mathematics are.

As indicated by the students' reflections, the CME tasks provided an opportunity to let students see connections between mathematics and other issues more clearly. Thus, the students' rigid thinking in

subjects can be counteracted, and at the same time, students' attributions of "math is everywhere" become more justifiable. Students can develop a greater awareness of the importance and role of mathematics in their individual lives as well as in our society. Therefore, regularly including CME in mathematics teaching might also be one possibility to counteract "the empty promise of the relevance of mathematics" (Kollosche, p. 638).

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