

## “Forced to flee” – Mathematical Modelling and Problem-Posing in 7<sup>th</sup> Grade

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### Abstract

In this paper, we investigate the characteristics of pre-service teachers' problem-posing activities involving a modelling activity related to the refugee crisis. We use socio-critical perspectives of modelling and problem-posing. We draw on data from one group of pre-service teachers' assignments and follow-up interviews, where they reported on their experiences of planning and implementing the modelling activity with 7<sup>th</sup>-grade students. After thematic coding, we identified multiple characteristics related to problem-posing. We focused on those regarding posing questions with the students relating to the refugee crisis, feeling the numbers, taking action against the crisis, and modelling for lived democracy. We consider these characteristics relevant for teacher educators in order to support problem-posing in modelling activities related to socio-critical issues.

I denne artikkelen undersøker vi egenskaper ved lærerstudenters tilrettelegging av elevers problemformuleringer i en modelleringsaktivitet knyttet til flyktningekrisen. Vi bruker samfunnskritiske modelleringsperspektiver til å se nærmere på en gruppe lærerstudenter som planlegger og gjennomfører et matematisk modelleringsopplegg på 7.trinn. Empiriske data består av et obligatoriske arbeidskrav og et oppfølgingsintervju, hvor lærerstudentene beskriver og reflekterer over undervisningsopplegg om flyktningekrisen. Tematisk analyse av data bidro til å identifisere flere egenskaper, bl.a. hvordan lærerstudenter tilrettela for elevers egne problemformuleringer relatert til flyktningekrisen, hvordan man opplever og føler tall, hvordan man kan agere på grunnlag av modelleringsaktiviteten, og modellering for et levd demokrati. Slike egenskaper er relevante for lærere og lærerutdannere for å støtte elevers og studenters modelleringsaktiviteter som involverer samfunnsaktuelle problemstillinger.

**Keywords:** Socio-Critical Modelling Perspectives, Problem-Posing, Refugee Crisis, Pre-Service Teachers, Primary School Students.

### Introduction

The current refugee crisis is unprecedented in scale, with more than 82 million refugees around the world. The refugees come from countries like Syria, Venezuela, South Sudan and Myanmar, and, more recently, Ukraine, yet the responsibility for accommodating refugees seems to be unevenly shared worldwide. For instance, within the last decade (2011–2020), major host countries (in percentages of the country's total population) were Lebanon (19.5%) and Jordan (10.5%), while Poland (0.01%) and Saudi Arabia (0.001%) had the lowest rates (Christophersen,

2020). Norway received approximately 1.3% of refugees. In Europe, pictures in the public news media with refugees crossing the Mediterranean Sea in crowded boats have made a deep impression. The disclaiming of responsibility has left countries like Greece and Italy alone in responding to the crisis and has led to inhumane conditions in refugee camps. The refugee crisis is receiving increasing political attention and causing controversies between, or even within, countries, for example, regarding the resources and knowledge that refugees bring with them. In Norway, where our study takes place, the rhetoric around the refugee crisis debate can be harsh and may discourage individuals from participating. In the long run, it can lead to a more polarised and disengaged society.

Education is essential in preparing school students to deal with complex societal issues like the refugee crisis. In the Norwegian curriculum for grades 1–10, it is emphasised that education should prepare students to live, act and participate in a diverse and democratic society (Ministry of Education and Research, 2020). In particular, it is mentioned that students should be able to analyse and solve problems from “real datasets and data collected from nature, society, working life and everyday life” and to form their own arguments and engage in societal debates (p. 4). Raising issues such as the refugee crisis in the classroom can provide students the opportunity to reflect on socio-political issues with their peers by using datasets, inquiring, and arguing mathematically. In the same curriculum, mathematical modelling involves activities that require critical reading and understanding of how models influence our lives and societies. The applications of mathematics and modelling are omnipresent in the refugee crisis, and the bridging of these allows for crucial issues such as politics and democracy to be challenged through the perspectives and sensitivities of young students. However, the bridging of mathematical modelling, democracy and refugees is underrepresented in previous research, even more so for empirical insights from pre-service teacher education.

In this paper, we bring attention to the socio-critical perspectives of mathematical modelling

and describe how they emerged during a modelling activity about the refugee crisis in a 7<sup>th</sup>-grade

classroom. Based on empirical data from four Pre-service Teachers' (PTs) experiences when including the refugee crisis in their 7<sup>th</sup>-grade classroom during their mathematics practicum, we focus on the *characteristics of PTs' problem-posing activities involving the refugee crisis*.

### **Previous Research About Mathematics Education and Discussions About Refugees at School**

Mathematics education research related to refugees and immigrants can involve issues such as language diversity and multilingual classrooms (e.g., Barwell et al., 2019; Planas, 2021), the language resources of immigrant or Indigenous students (Ryan & Parra, 2019), xenophobia (Hauge et al., 2019), and inclusive family engagement (Civil, 2020; Karsli-Calamak et al., 2020). The focus of such research has been, for instance, conceptual understanding of mathematics (Prediger et al., 2019), outdoor measurement (Rangnes & Meaney, 2021), or numeracy and proficiency (Lüssenhop & Kaiser, 2020; Schipolowski et al., 2021). Few research papers use the topic of refugees as an issue in the classroom, but some examples do exist. For instance, Bousalis and Furner (2020) linked middle school mathematics to immigration issues in the United States while addressing a multiculturally sensitive citizenry. They described how teachers built culturally responsive classrooms and facilitated students' inquiry into and reflections on immigration in society to challenge anti-immigrant discourses dominating the U.S. media. Yet, addressing these issues might be challenging for teachers and students. It requires teachers to be prepared and sensitised to tackle students' emotions and potential discomfort. The authors suggested students could examine immigration through a historical lens and then reflect on present-day migration issues, for example, immigrants' contributions to society, culture or demographics.

In another study involving a modelling task about refugees, Vorhölter et al. (2019) described students' alternative suggestions for distributing the 1.5 million refugees who arrived in Germany in 2015. The students considered aspects such as shortage of living space and empty houses to avoid pressure in an already strained housing market, aspects which were not considered in the state's original relocation model based on taxes and population. These studies, though few in number,

show that integrating issues about immigrants and refugees in mathematics classrooms raises multiple concerns for mathematics education and research.

### **Socio-Critical Mathematical Modelling Perspectives**

Socio-critical modelling perspectives focus on a critical understanding of the world and the role of mathematics in society. Barbosa (2006) highlighted that modelling should be a problem (not an exercise) for the students and should be extracted from everyday activities which are not just pure mathematics. Students can use mathematics to examine the world critically and act upon injustices. Modelling, as understood in this paper, provides a pathway for giving opportunities to students to inquire, discuss, and engage with critical issues and, thus, to be part of a lived democracy. According to Hauge et al. (2022), lived democracy involves learning through democracy rather than about and acting through argumentation beyond learning in the classroom.

The refugee crisis affects people and societies worldwide, and living with this crisis is likely to be, according to Skovsmose (2021), a perpetual phenomenon. He highlighted that mathematical modelling can provide “pictures” of the refugee crisis, and by investigating its mathematical representation, one can better understand the crisis itself. Thus, mathematics could become part of the solution to the crisis by forming our perception of it and how we act on it. It could also be a representation of particular worldviews. According to Skovsmose (2019), the perspective taken has often been from the wealthiest countries in the world, and the references to a crisis may have been “used for justifying constructions of new walls” (p. 2). For instance, the term “refugee crisis” was used to describe a situation in 2015 when refugees crossed Europe’s borders.

The ability to “feel” the numbers is relevant in issues concerning the refugee crisis because emotions play an essential role in decision-making and human action. Renert (2011) described that the “inability to feel large numbers” can be problematic (p. 21) if decision-makers do not fully understand the magnitude of a problem or issue. Even though he referred to environmental issues, not feeling the refugee numbers can be equally problematic. In a related paper, Mukhopadhyay and

Greer (2007) suggested including “statistical empathy” in mathematics education, which they described as “the ability to relate statistical data to the reality of what they stand for” (p. 119). They highlighted that students hardly spend time discussing social contexts, implications, or sense-making activities when dealing with statistical data. They described how graphs of the deaths of refugees crossing the U.S.-Mexico border stand alongside pictures of crosses and coffins to avoid the stance of neutrality often adopted by mathematics educators. When bringing in the ability to feel the numbers, a timely question is if one should impose on the students the severity of what the numbers represent. According to Abtahi et al. (2017), teachers can avoid exposing their students to challenging real-world issues out of concern for their students, similar to the discomfort that Bousalis and Furner (2020) mentioned. However, since students are most likely already largely exposed to these issues through the internet or the news, raising these issues in the classroom provides them with an opportunity to be supported by each other and have these challenging conversations together.

The feeling of hopelessness can accompany challenging real-world issues like the refugee crisis. Therefore, providing students opportunities to feel hope and take action is essential. Gutstein (2006) underlined the relevance of teaching students to read and write the world with mathematics and highlighted that writing the world is complicated for students because it entails taking action. He suggested that teachers provide opportunities for students to take action and “to understand commonalities they have with others” (p. 95) by, for instance, providing spaces to pose their own questions or write letters to people in charge. By providing students with the agency to act, mathematics education can empower students with hope (Ryan & Steffensen, 2021).

Posing mathematical modelling problems and implementing them in the classroom can be challenging (Borromeo Ferri, 2018). Hansen and Hana (2015) suggested a shift in education, focusing on students’ posing questions instead of answering them, to enable them “to act and to further their understanding of the world” (p. 40). They connected problem-posing to the initial phases of the modelling process and described PTs’ challenges in these phases. For instance, one

challenge was when PTs invited students to pose problems about plants but did not use their suggestions because they “were to a large degree non-mathematical” (p. 37).

Reed et al. (2015) connected problem-posing to liberatory education (Freire, 1985) and highlighted that a “culture of silence” prevents people from taking part in transformations of society. To break that culture, students and teachers as learners need to be reflective and critical of their relationship with the world and subsequently take action to change the world collectively. Introducing socio-critical perspectives in posing modelling problems can, on the one hand, add to the challenges described by Borromeo Ferri (2018). On the other hand, experiencing modelling from these perspectives can become more meaningful to students by facilitating a culture where they actively engage in societal issues. Jung and Magiera (2021) described that posing social-justice-oriented modelling problems could occur by discussing “political, social, cultural, and economic structures” and “distributions of resources, power, and privilege” (p. 4-5). These issues should be framed within a realistic context allowing assumption building, inviting model development, encouraging shareable processes, and connecting to students’ lives.

Meyer (2011) suggested Mathematics In Three Acts (MITA) as a method where students should pose, explore and discuss problems collaboratively. In Act 1, the teacher presents a situation through visual illustrations relevant to students’ lives to enable them to pose questions. Students discuss which question(s) to pursue and explore using mathematics. In Act 2, students work in groups to find the information, tools and resources that would help them solve the problem they have posed. In Act 3, they use the information, provide answers, and present their work to the class.

Examples of MITA connected to Meyer’s (2011) modelling tasks are often framed around practical everyday situations. However, less is known about connecting MITA with modelling activities from a socio-critical perspective, let alone how PTs experience them in primary schools. In Norwegian education, Zhou and Hansen (2022) investigated PTs’ group assignments involving MITA during their practicum in grades 1–7. We consider this research relevant, as the examples of modelling activities described by PTs in their assignments provided insights about what aspects of

modelling PTs focus on. Zhou and Hansen (2022) found that, although PTs identified realistic contexts for posing questions related to students' social world, e.g. climate change and its future implications, they did not reflect further on the modelling process after Act 3. Therefore, posing problematic situations in Act 1, which can potentially lead to socio-critical modelling activities for Act 2 and Act 3, was not connected to the aims of taking action to affect a change of the situation. In the problem-posing perspective we adopt in this paper, inspired by Freire (1985), we support that action is an important part of engaging with modelling, especially regarding socio-critical issues such as the refugee crisis. This is mainly because taking action can lead to a feeling of "hope" (Reed et al., 2015), which adds to Gutstein's (2006) suggestion of a sense that students and teachers do actually have the potential to have an impact on society and change a situation which was harmful or unjust.

## **Methods**

To investigate the characteristics of PTs' problem-posing activities, we use a group of second-year PTs as a case study. Case studies allow us to analyse the situation and understand it holistically in its context. We use sources of contextual data, including the PTs' group assignment, interviews, and teaching material. We chose this particular group because their modelling activity involved socio-critical perspectives. The PTs had designed and implemented a modelling activity about refugees during their practicum, named "Forced to flee" [På flukt], which they described in a written assignment required by the mathematics education course. The group consisted of Vilde, Anna, Mai, and Saga (pseudonyms).

The mathematics education course took place in the first semester of the second year of a five-year teacher education program. The PTs attend practicum in all five years of the program. The second author of this paper was the Teacher Educator (TE) in one out of three workshops on mathematical modelling that PTs had before practicum. In the workshop, PTs were introduced to MITA, Barbosa's (2006, p. 294) features of a modelling activity, and the problem-posing

methodology of Wallerstein (1987, as cited in Reed et al., 2015). The TE utilised examples of school students' questions posed in a modelling activity and invited PTs to reflect, firstly, on the importance of encouraging all students to pose their own questions in mathematics classrooms and secondly, on teachers' role in handling students' mathematical and (initially) non-mathematical questions. This reflection task was followed by a critical theorising of problem-posing related to problematising social justice issues in the world (Freire, 1985). Emphasis was also given to the teacher's role in problem-posing in language-diverse classrooms, based on students' shared ideas, interests, resources, experiences, personal stories and backgrounds and encouraging them to take action and change problematic situations (Reed et al., 2015).

The PTs' practicum took place in the 7<sup>th</sup> grade of a Norwegian compulsory school (12–13 years old). The classroom had 24 students, of which seven spoke an additional home language, in addition to Norwegian. Most of the students with multilingual backgrounds were born in Norway, but some had parents who were refugees or immigrants. Apart from giving written feedback in the students' home languages, the PTs did not particularly focus on multilingual students or students who are second-generation immigrants and how they supported them in using their resources during the modelling activity. Therefore, the refugee crisis was not related to the migration background of the classroom but was used as the topic of discussion. The practicum classroom teacher gave the PTs responsibility for assigned lessons and informed them that the refugee crisis was the current focus at the practicum school. "Forced to flee" was an interdisciplinary activity between mathematics and social studies (4 x 60 min). The PTs introduced the situation in Act 1 with a



collection of pictures of refugees (1–4) and text (5) with numerical facts extracted from media news

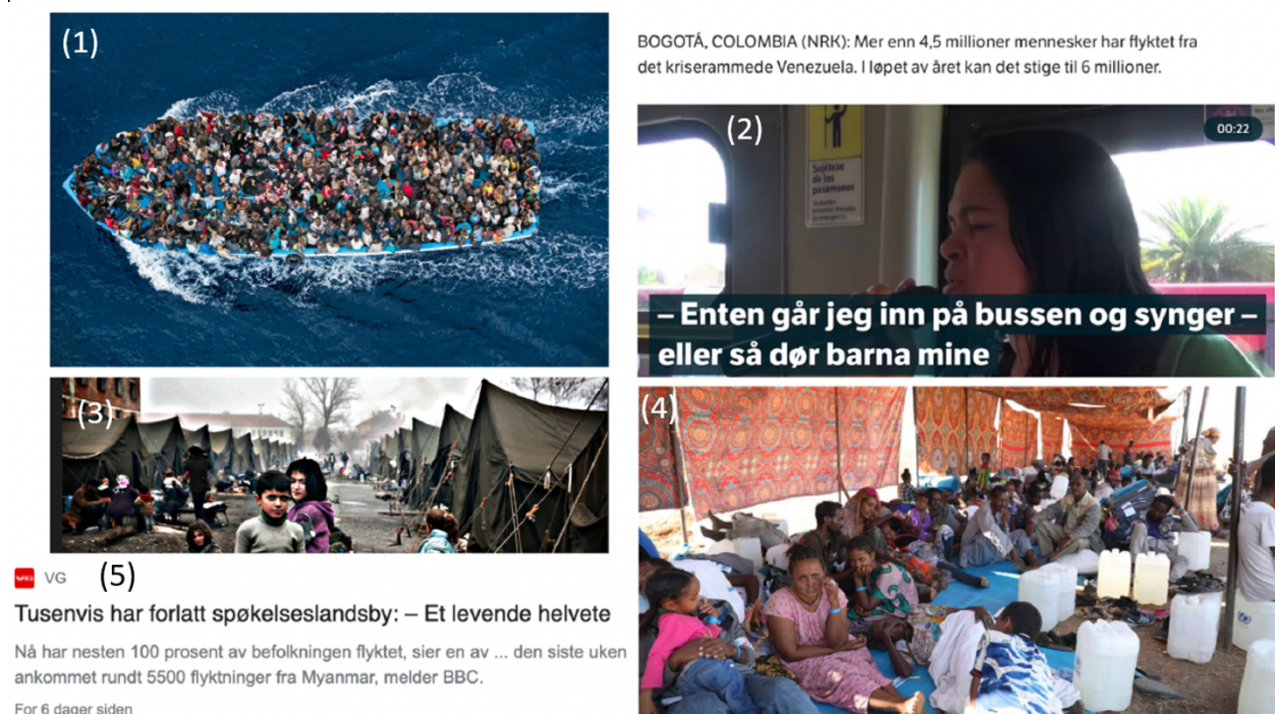


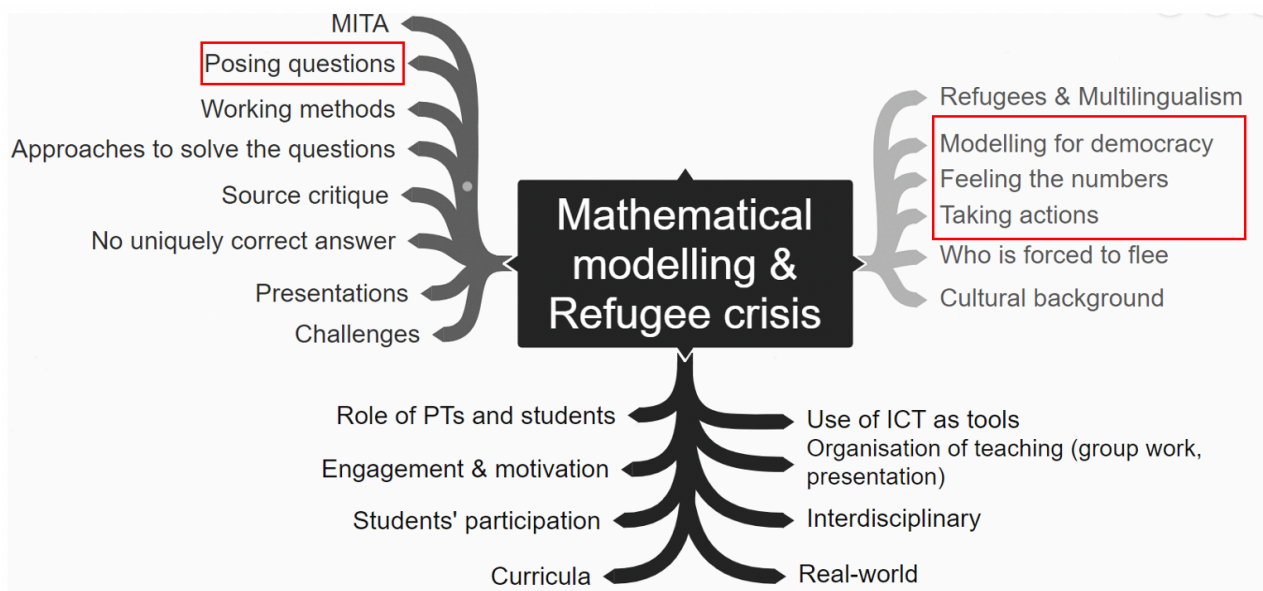
Figure 1 Pictures and media texts used in Act1 to introduce the topics to the students. Photo: (1) Refugees in boats from Libya (Sestini, 2014), (2) Refugees from Venezuela (Stefansen, 2020), (3) Refugee camp in Bulgaria (AFP, 2016), (4) Refugees from Ethiopia (Ali/NTB/AFP, 2020), and (5) Refugees from Myanmar (Lyngstad, 2021).

(Figure 1). They asked students to pose relevant questions they might want to investigate. In Act 2, the students worked in five groups and explored their chosen problems. In Act 3, students presented their findings in posters and discussed different solutions to the issues. The posters were addressed to the Norwegian Refugee Council (Flyktningshjelpen) to support their readers in understanding the refugee crisis. During the PTs' teaching, the regular teachers were in the classroom observing. Afterwards, they received feedback from the teachers on things such as the content and what they noticed.

We proceeded to a follow-up interview to gain further insight into PTs' experiences and reflections on the modelling activity. For practical reasons, we conducted one group interview with Vilde and Anna and a separate one with Mai. Interviews were audio-recorded and transcribed. The interviewer (first author) asked clarifying questions so that PTs would elaborate on their modelling activity. For example, PTs had provided little information about Act 3 in their assignment, thus we

purposefully requested them to explain and reflect on Act 3. The interview consisted of three main parts, prepared in a semi-structured interview guide. Part one focused on PTs’ choice of the topic of refugees for mathematical modelling. Part two, the longest one, concentrated on PTs’ reflections on students’ work and on PTs’ roles. Here, particular focus was given to the problem-posing phase of modelling. Part three focused on the classroom demographics, including linguistic and cultural backgrounds.

Our data sources include the PTs’ assignments, interviews, lesson plans, students’ notes and the TE’s teaching material. The information from these sources was contrasted and thematically coded (Figure 2). In this paper, we focus on four topics: “posing questions”, “feeling the numbers”, “taking actions”, and “modelling for lived democracy”, chosen due to their relevance and



**Figure 2 Themes from the analysis, with the four chosen topics highlighted in red.**

representative content for the research question. The previously described theoretical perspectives provided insights into our analysis (e.g., designing the interview guide and coding) and discussions.

## Results

### Posing Questions

One feature of the PTs' problem-posing activity involves *how they connected mathematics and refugees*. The PTs argued that they chose the context of refugees because, for them, it is about mathematics and is to do with numbers about people. For instance, Mai expressed that the refugee context "is really very, very mathematical because there are always graphs, statistics, numbers, and involve so many people that in a way it is unbelievable".

A second feature concerns *how PTs presented the context to students*. According to Mai, they showed the chosen pictures because they could get them "thinking of numbers and mathematics and create many questions". She said they wanted students to feel free to pose all kinds of questions and base their inquiries on their own interests, thoughts, and questions arising from these pictures. This shows that they used ideas from the teacher education workshop (e.g. using pictures for problem-posing and Barbosa's contextual framing) and further developed these ideas to include the refugee crisis. In both examples, Mai related the refugee crisis with mathematics in line with Gutstein's (2006) reading and writing of the world with mathematics.

A third feature involves *how PTs broadened the context*. They expressed concern about who was "forced to flee", and about wanting to raise students' awareness of refugee crises not highlighted in the media. They aimed to: "represent other continents and countries one may not have heard of in connection to refugees. You often hear about Syria, but you may not hear about Myanmar as much" (Anna), and to "give students a broad perspective and that you can talk about all these issues, refugees are not just those who are in a boat" (Mai). Therefore, for them, bringing awareness to the people who are "forced to flee" mattered and did not only involve a European-centric perspective. Their decision to direct students' gaze on refugee crises in other parts of the world aligns with Skovsmose's (2019) thoughts on who defines what the crisis is. However, except for one group of students focusing on refugees in Mali, students chose to focus on the context of

more familiar with this context or because the local media focus less on “distant” situations. For example, pictures of boats from the Mediterranean have frequently been circulating in the media, and Anna said that boats were what the students posed questions about right from the beginning.

A fourth feature includes *supporting the students*. The PTs designed the activity so that students would first discuss which questions to explore in groups and then present these questions in plenary. According to Mai, they wanted the students “to feel safe” to pose questions and “hide behind the community of a group”. Mai said that she encouraged students with comments like, “Wow, what an exciting question”, because it was “crucial to cheer on the ideas from students [...] then they will find joy in creating new ideas, and keep getting better”. She said that her role as a teacher is to “provide wide enough space” for students “to inquire and explore ideas”.

A fifth feature involves *how PTs mathematised the context for students*. The PTs wrote students’ questions in two columns on the whiteboard (Table 1).

Mathematical questions	Other fact-based questions
How many people is there room for in the boat?	What has happened in their home country?
Will somebody fall out?	Where are they travelling from?
Are there more refugees in other places?	Where are they travelling to?
How many receive help?	Why are they fleeing?
	Do they get food?
Mathematical questions [in Norwegian]	Other fact-based questions [in Norwegian]
Hvor mange har plass i båten?	Hva har skjedd i hjemlandet?
Faller noen ut?	Hvor reiser de fra?
Finnes det flere flyktninger andre steder?	Hvor reiser de til?
Hvor mange får hjelp?	Hvorfor flykter de?
	Får de mat?

**Table 1: Students’ questions from Act 1**

The table shows that all but one question was posed in the present tense rather than the past. This indicates that students’ questions went beyond understanding what was happening within the pictures they observed and were instead set out to holistically understand a crisis, its conditions and implications. Mai asked students why there were two columns, and after she heard their suggestions, she then explained that the “questions on that side do not involve numbers, but these

involve numbers or quantity and so on”. By engaging students in reflections about the nature of the questions, they became aware of these nuances. Furthermore, contrary to what Hansen and Hana (2015) described, the students actually posed mathematical questions. It should also be pointed out that some questions which were initially categorised as non-mathematical, e.g. where refugees travel to, became mathematical when students made spreadsheet overviews of refugees in Europe. Thus, they had an in-context experience that mathematics is not just numbers.

A sixth feature involves *challenges in problem-posing*. Mai said the biggest challenge with modelling is “to find the balance between having a task concise enough for the students to understand what they should do, but still open enough for them to formulate their own problem and inquire about this”. They experienced the process of problem-posing challenging, similar to what Borromeo Ferri (2018) and Hansen and Hana (2015) described. However, it should be noted that they did succeed in enabling students to pose questions.

### **Feeling the Numbers**

We identified at least three examples of what we refer to as “feeling the numbers”. Two of these examples include *seeing what the numbers actually represent*, from the PTs’ and the students’ perspectives, respectively. For example, Anna stated that she wanted students to “form their own views from the numbers they found. Because it is not just numbers; it is about people dying”. She emphasised what the numbers represented and the severity of the situation. The second example concerns a group of students inquiring how many refugees receive help in Norway. They wrote: “50% of refugee children attend school. However, that means that 50% do not attend school and do not have a good life”. The first part of the sentence is sufficient to show how many refugees receive help (in this case, attend school). Still, the students did not stop there; instead, they continued and contrasted it with how many do not receive help by turning the first interpretation of the percentage around. One can quickly become distant from what numbers, statistics and graphs represent, as described by Mukhopadhyay and Greer (2007). However, by focusing on what 50% actually means,

in this case, not having a good life, students were able to “feel the number” and consider the possible impact on the life of children who do not attend school.

A third example involves *the (in)ability to feel large numbers*. A group of students identified the substantial number of 82.4 million refugees worldwide. According to Mai, the students sensed that this number was too large to grasp and wanted to translate it into a percentage so that “they in a way could understand this better [...] because the numbers of refugees are so large, and they are too large to understand”. Large numbers can be hard to imagine, and when students turn these into more manageable and understandable representations, it can improve their feeling and understanding of what they represent. As Anna stated: “So it was like passing on the numbers to a kind of representation, a share”. Interestingly, both students and PTs showed awareness of what Renert (2011) described as our inability to feel large numbers and took steps towards a better understanding.

A fourth example involves *emotional constraints and awareness by feeling the numbers*. Vilde stated that the students showed awareness about the refugee crisis by working with the numbers when they said, for instance, “Oh, is it that many who die?” The PTs also expressed their own awareness of the sensitivity of the issues of refugees in potentially affecting students’ emotions and emphasised it was essential to know the students’ background. Despite the challenges, the PTs did not avoid this topic, as seen in previous research by Abtahi et al. (2017). Instead, they recognised the advantages of students working and reflecting together to understand the numbers and the mathematics connected to refugees.

### **Taking Action**

The third first characteristic is about taking action. For this characteristic, we observed the most connections from the teacher education level to the PTs’ teaching and to students’ learning about mathematics and society. We identified three perspectives of what we label as taking action.

The first is the *teacher educator’s teaching*. Ideas from the TE concerning teachers’ role in problem-posing, taking action and raising awareness of (in)justice in society were observed in the

PTs' work. For instance, in their lesson plans, they noted: "Take action, what can we change", "who is affected", and "how does this affect us and our personal histories", phrases taken directly from the TEs' PowerPoint slides. Moreover, their choice to include a wide range of refugee inflows and not only refugees arriving in Europe by boat indicates PTs' increased awareness of injustices and a willingness to take action in the classroom towards understanding these injustices and how to change them. Although the relationship between the teacher education context and the school context exceeds this paper's limits, the focus from the TE's perspective seems relocated amongst the PTs.

The second perspective is *the PTs' teaching*. The PTs explained that they wanted students to know that mathematics is an important part of their lives and society and took standpoints which point to classroom actions beyond the school level. Some examples were when Anna said they wanted "students to form their own standpoints from the numbers", and when Vilde and Anna suggested they could engage their students in "volunteering as a refugee friend", "inviting students to suggest how they think they could help" and visit asylum reception centres "to play games or get to know people". The PTs drew parallels to the climate change crisis, where students showed engagement and involved their families. This modelling activity happened before the war in Ukraine. However, this shows that their ideas and actions could have applications in issues of the present day, as Bousalis and Furner (2020) suggested should be done, as the refugee crisis continues. Students across Norway currently seem to engage with the refugee crisis caused by the war in Ukraine by collecting bottles and clothes, or selling baked goods to donate the proceeds to the Red Cross. The agency to act may empower the student who provides help, which aligns with what Ryan and Steffensen (2021) described, and give hope to those receiving the help.

The third perspective is *PTs' and students' standpoints*. Anna stated that regarding refugees in Norway, "I think we receive too few refugees. This correlates with the numbers we found [during group work] and compared to the economy we have". Thus, mathematical representations do not only bring about awareness; they can format our actions in the refugee crisis, as described by

Skovsmose (2021). During students' discussions in groups and in plenary, the PTs also noticed that their inquiries about the refugee numbers brought attention to differences in how many refugees countries receive. Anna and Vilde said that some students were surprised by how large the total number of refugees is and how small Norway's amount is, as shown by their wondering. For example, "What are we doing?", "Oh, we receive a small number of refugees in Norway", and "What can I do?". Thus, they developed awareness and expressed a willingness to act. In addition, students' statements on the posters were a form of action addressed to the Norwegian Refugee Council and its readers, which seems in line with Gutstein's (2006) suggestions. By adding this audience, students' mathematical work became a responsible political action with implications for society.

### **Modelling for Lived Democracy**

We identified at least two features regarding modelling for lived democracy. The first is *argumentation and taking a stand*. Anna explained that their "modelling activity provides tools to students to make argumentation and inquire. [...] to be able to take a stand on societal issues and form their opinion based on facts", and Mai said that "modelling can be an excellent way for students to think for themselves, formulate thoughts and form their own standpoints". Both connected modelling to forming standpoints relating to developing argumentation, taking or influencing action through argumentation as emphasised in the curricula (Ministry of Education and Research, 2020) and in previous research about students' lived democracy (Hauge et al., 2022). The second feature is *an inquiring human taking part in society*. Anna underlined that modelling enables students "to take part in society" and that "we [teachers] give them the tools to become a human being who is inquiring and wonders about issues in society". She pointed both to how schools can engage students in being inquiring human beings and in taking part in society. Also, Mai stated that students should "feel that they are important [...], not just sit there as consumers of the teachers' production". The classroom constitutes an essential part of students' lives, and just sitting and not



opportunities of modelling for lived democracy realised in the classroom, strengthen the idea that preparing students for society outside the classroom is not possible unless students experience and live democracy inside the classroom (Hauge et al., 2022).

### Concluding Comments

In this paper, we investigated the characteristics of one group of PTs’ problem-posing activities involving the refugee crisis. We took a socio-critical modelling perspective and described four relevant topics (see Figure 3).

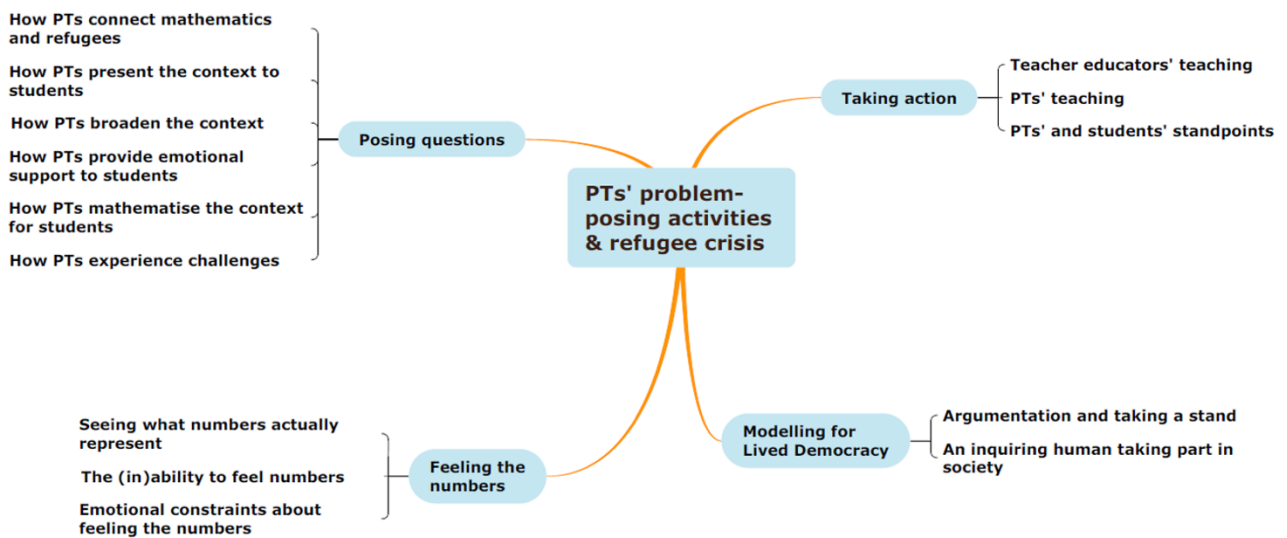


Figure 3 Characteristics of PT’s problem-posing activities involving the refugee crisis.

The characteristics of problem-posing we identified were across the three acts of the modelling activity rather than just the first act. However, through PTs’ descriptions, we saw that the binding characteristic is modelling for lived democracy. The PTs’ descriptions show that the refugee context was important for them to discuss with their students, not only because of its mathematical and statistical relevance but also because of its societal, political and affective dimensions. We were initially surprised that the PTs did not refer to their students’ multicultural or migration backgrounds as reasons for choosing to work with this topic. This expands our view of what a migration context is and what kind of activities are suitable for a “regular classroom”, in that

neither the teacher nor the students need to have a migration background to problematise the refugee crisis through mathematics.

The PTs reflected on the pedagogical challenges of problem-posing in mathematical modelling and described them in relation to student-guided inquiries. We see these connected to their reflections on their role as mathematics teachers and using democratic practices. They frequently referred to their pedagogical choices concerning letting go of control of the information they provide to students to give them space to inquire, discuss, and explore the refugee crisis based on their genuine interest. When it comes to taking action, we see this connected to PTs' wishes for students to experience modelling for lived democracy in the classroom (Hauge et al., 2022). For example, PTs deliberately aimed to represent the minority of refugees and raise students' awareness in order to encourage them to do more inside and outside the classroom. In addition, actions such as becoming volunteers relate to feelings of hope and willingness to change a situation after engaging in a modelling activity. Posing problems in a modelling activity from a socio-critical perspective can spark a desire to change and participate actively in understanding and operating in the real world.

The study's limitations (e.g., the fact that only three out of four PTs participated and only part of the assignment was included) should be considered. However, implications remain for TEs to focus on problem-posing in mathematical modelling in their respective courses, as the literature recognises this topic as challenging. Furthermore, teachers and TEs have an important role in engaging students in contexts like the refugee crisis and including elements of hope and action.

Problem-posing connected to socio-critical modelling can influence not only how we view the refugee crisis of the past but also how we respond to it in the future. To conclude with a hopeful note, like the students in the classroom, we turn to Anna's statement about refugees in society: "I think of refugees as a resource. They come with a lot of knowledge and they come with a lot of experience. So, I try to look at refugees from a resource perspective more than as a very big

problem. [...] to potentially open up the classroom to more refugees, because then people may also [do so].”

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