MatheConnect: Integrating Socially Relevant Topics into Mathematics Education

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Abstract

Austria's national curricula and international educational initiatives emphasize the importance of interdisciplinary competencies across all subjects. However, incorporating socially relevant topics into mathematics education remains a challenge for teachers, textbook authors, and researchers. The project MatheConnect addresses this challenge by involving us—students from BG|BRG St. Martin in Villach—as Citizen Scientists. Through our participation, we contribute to data collection, analysis, and the development of interdisciplinary teaching materials that make mathematics more relevant to real-world issues.

In our research, we explored which societal topics students, and the public consider meaningful for inclusion in math classrooms and which methods are suitable for identifying these interests. We used a variety of instruments, including surveys, interviews, and creative tools such as "future boxes" and flyers—adapting our approaches based on age groups and target settings. Each method brought different insights and challenges.

Our work also revealed valuable lessons about group collaboration, tool selection, and the influence of survey design on data quality. As actively involved students, we share our experiences, key learnings, and reflections, showing how student-led research can inform interdisciplinary teaching and support more engaging, socially relevant math education.

Keywords: *mathematics education, citizen science, data collection tools, data collection*

Introduction

National and international debates about education show the importance of interdisciplinary teaching and cross-curricular competencies. The main competencies of the 21st century—known as critical thinking, collaboration, communication, and creativity—are key to educating students to succeed in today's workforce. However, implementing these competencies in mathematics education seems to be especially challenging for teachers, textbook authors, and researchers. In particular, combining socially relevant topics with mathematical content appears to be quite difficult. At the same time, research highlights the importance of bringing relatable content and areas of authentic application into the classroom. But who knows better what moves today's young people than the students themselves? The "Sparkling Science" project *MatheConnect* is a government-sponsored research project that focuses on the role of students as citizen scientists. In this project, the Institute of Mathematics Didactics at the Alpen-Adria University of Klagenfurt collaborates with two classes (6A and 7A) from the BG|BRG Villach St. Martin to involve students in the process of collecting and evaluating data, as well as in giving feedback on lesson plans and authentic content.

Research Objectives

The participation of students in the research process should specifically lead to the identification of topics relevant to young people so that these can then be incorporated into mathematics lessons. The aim is to develop learning environments for the lower and upper grades that authentically address overarching topics and are geared towards the interests of the students.

The guiding research questions of the project are

- Which interdisciplinary, socially relevant topics students of different school levels consider interesting and relevant for integration into mathematics lessons, how this can best be assessed across school levels, how these topics can be linked to appropriate mathematical content (= task creation) and what feedback on created tasks students and teachers give?

In the following research report the focus is on the following questions:

- What challenges and learnings do students have when they work on a research project?
- Which methods or instruments do students choose to identify students' interests?

Theoretical framework

Since the beginning of the twenty-first century, the term citizen science has been used more and more frequently. It is not only being used in a scientific context, but the term is also being used increasingly often in the media. It should be emphasized here that this term emerged primarily in European countries and the USA and a while later was the term also used in Asia and generally in the southern hemisphere (Strasser et al., 2018). Despite the frequent use of the term citizen science, it is very difficult to define. Haklay et al. (2018) alone list over 30 different definitions and state here that this is not an exhaustive list.

In this research report, the term citizen science is used in a very general way. The term citizen science is used when non-professional people (called citizen scientists) are involved in science (Gura, 2013).

Despite these people are not trained in science they have the opportunity to take part in research projects. The roles of the Citizen Scientists differ from research project to research project. The Citizen Scientist for example can help in the process of collecting data, categorizing, transcribing or analyzing scientific data (Bonney et al., 2014). This shows that the Citizen Scientists can be part in every research step.

Benefits of Citizen Science

Citizen science projects offer many benefits for both science and society. They allow everyday people to take part in real scientific research, helping to collect data, make observations, and even analyze results. This makes science more open and inclusive. For participants, it's a great way to learn new skills, understand scientific processes, and contribute to important discoveries. Scientists benefit from larger data sets and new perspectives. (Shirk & Bonney, 2018)

History of Citizen Science

The consideration of the history of Citizen Science is limited and only partially helpful, since almost all discoveries made before the middle of the 19th century can be regarded as discoveries by amateurs. In most cases, e.g. Darwin, these people made discoveries outside their field of work, i.e. they regarded research into a particular subject as a hobby, so to speak. Comparing the role of Citizen Science before the middle of the 19^{th} century is not useful because it would be more comparing amateur naturalists and citizen science. In earlier times, science was understood quite differently than it is today. It was often practiced in the home, as a part of one’s personal curiosity or leisure, rather than as a formal profession. Only with figures like Charles Darwin did science begin to professionalize. This marked a shift toward systematic research, institutional support, and a clearer separation between private life and scientific work. This shift offers the opportunity to talk about Citizen Science.

Citizen Science Engagement

The number of scientific projects that include Citizen Scientists in the research process is increasing. The increase can be explained by different societal and technological trends. First of all, since 1950 more and more people get a higher education that in the decades before. Besides the development in education and especially in scientific thinking, people in high- and middle-income countries have more leisure time because of the reduction of working hours per week. Additional leisure time offers the people time for other activities like taking part in a research process as a citizen scientist. In addition, the retirement age did not change that much comparing to the increase in the life expectancy. People are staying longer healthy and due to their retirement; they have enough time to take part in a research project. As mentioned, there are not only societal trends that support the increase in citizen science projects. Technical improvements offer way more opportunities to reach and involve Citizen Scientists. Researchers can reach easily more people than before the digital age, because as an example in Europe nearly everyone has a mobile phone and access to the internet. (Vohland et al., 2021)

Focusing on Europe, the engagement of citizens in science differs (Vohland et al., 2021). It is particularly striking that countries with a high democracy index also have a higher level of citizen participation in science (Makarovs & Achterberg, 2018). If attention is paid to which countries themselves publish reports on the topic of citizen science, it becomes apparent that it is primarily Western countries such as UK, Switzerland, France, Spain, Germany, Austria that do this (Vohland et al., 2021)

Different countries fund citizen science project in different ways. In Austria and Germany, the federal ministry sees a in citizen science a huge chance to give citizens the opportunity to take part in scientific projects. As citizens are actively involved in the research work, they gain experience of how scientific work actually takes place. They get an impression of it and thus the understanding of science should be strengthened. In addition to an improved understanding of science, these countries want to discover new innovations and use this opportunity to answer scientific questions that might not be possible without the involvement of citizens. (Vohland et al., 2021).

In Austria there is a huge funding by the Federal Ministry of Education, Science and Research (since April 2025 Austrian Federal Ministry of Women, Science and Research) for Citizen Science Projects. All these Citizen Science Projects are so called Sparkling Science Projects. The focus of the Sparkling Science Projects is engaging scientific institutions (e.g. Universities, Universities of Applied Science, …) that work together with students. These students take the role Citizen Scientist in these projects. The focus of these projects differs. The following percentages give an overview on the disciplines the projects are focusing on. 28 % on natural science, 20 % on teaching and learning research, 20 % on social science, 13 % on humanities, 8 % on humanities, 8 % on technology and 2 % on informatics. This research paper also presents the results of a Sparkling Science project, which can be categorized as teaching and learning research. (Österreichische Agentur für Bildung und Internationalisierung [oead], 2025)

Sparkling Science projects are special Citizen Science projects, as the Citizen Scientists are students. In contrast most Citizen Science project focus on adults participating in their leisure time despite students could engage take part already during school. Citizen Science would be one way of conveying the relevance of content to pupils. Instead of generating data, working with it and then never using it again, Citizen Science offers the opportunity to use it further and show students that their work has an impact. Besides the motivational aspect Citizen Science projects bring with them they also might have similar benefits as for adults. (Harlin et al., 2018) Two main benefits as stated before are the increase in scientific literacy and how students think about science (Zoellick et al., 2012; Vitone et al., 2016). Citizen Science projects in general support a positive feeling about science and leads to positive attitude towards scientific work (Vitone et al., 2016).

The research project

Harlin et al. (2018) mentioned three different models to bring citizen science into schools. In the first type existing programs would be adopted and adapted. If the citizen science approach is an autonomous local development, then type 2 is used. The third type of a citizen science approach is existing, if there is a local partnership between scientists and teachers.

The Citizen Science Project MatheConnect can be categorized as type 3. Scientists of the University of Klagenfurt and the University of Dundee are working together with students and teachers of the BRG|BG St. Martin in Villach. This project is also a Sparkling Science project which means that it is funded by the Austrian Federal Ministry of Women, Science and Research.

Methodology

As mentioned before MatheConnect is a Sparkling Science Project which started in September 2024 and will continue until June 2028. The students of the BG|BRG St. Martin in Villach (Carinthia, Austria) work together with researchers of the University of Klagenfurt. The participation of the students is very important to ensure the possibility to answer different research questions. Beside the scientific interest of the research process, it also enables the students to use their ideas to shape future learning material.

The whole project can be divided into three main parts. The first part takes place during the schoolyear 2024/25, the second starts in summer 2025 and the third is planned for the schoolyear 2025/26. The current focus is on creating the survey instruments and answering the question of which topics 21st century pupils would find exciting for school lessons. Learning materials will then be created in the summer and an evaluation phase of these materials will begin in the fall. The scientific report will focus on the first part.

Students' ideas are crucial to answering the question of which topics pupils find exciting for school lessons. In order to find out what ideas the students have for the survey, they were first familiarized with the theoretical content of critical mathematics education and the basics of scientific work. They have learned about these things in different workshops. After these workshops, the students were assigned to individual groups. The students could choose between the following groups: Group 1: Development and creation of the survey instrument, Group 2: Implementation of the data collection, Group 3: Data analysis. After first brainstorming meetings of the first group there was a meeting with the whole students-research-group to discuss the ideas. The ideas from the plenary discussion were then taken into account when creating the survey instruments. As soon as the survey tools were completed, the second group began its work. There was also a very quick transition for group 3, which took the data directly and began to evaluate it.

The description shows that the students built up a lot of new knowledge through various workshops and discussions and received support in all steps of the research process.

Results

Tools

This group was responsible for the survey instruments with the main goal to collect data and later on evaluate them, based on the results.

Survey instruments – general public: Stickers and flyer

Having this in mind it was necessary to consider the following measurements. Primarily, it was crucial to decide on which type of instruments should be used in order to differentiate between the important and unimportant information and simultaneously reach a variety of different people, also the elderly ones to include the whole society and it's individual opinions in the process. After having this accomplished, another key factor was to become aware of which information should be received including the personal data of the participants, without offending them in some way. In order to achieve this, questions had to be asked in a suitable fashion – On the one hand providing an input for the candidates as well as encouraging them to think out of the box. On the other hand, it was pivotal to avoid limiting their personal ideas. Furthermore, it was essential to ensure that the length of the surveys is not immense and that most of the participants finish the questions and put as much effort in it as possible. These considerations enabled to establish following results.

Figure 1: Flyer for general public without mathematical connection

This resulted in two polls, which asked for different perspectives of the similar topic. The major difference was that one of them informed the people about the relation between mathematics and topics regarding the society, whereas the other one was just about the social aspect. The reason was to find out if the two different formats have an impact on the people's answers. The surveys were accessible through QR-Codes printed on stickers and flyers.

Starting from scratch, the main challenge was to come up with a plan and finding compromises within the group itself. Learnings, which were taken from the entire process, were improving the cooperative skills as well as gaining experience in scientifically research and development.

Figure 2: Flyer for general public with mathematical connection

Survey instruments – schools: Future boxes

The first thing we noticed was: it is really difficult to think differently in a very regulated and very rugged system. Every survey model is generally a different variation of the same thing and we were so happy to finally figure out a system that functioned well and was doable. Which is the next issue we had: A lot of the ideas we had were not realistic and at times even very creative but just impossible for a bunch of students to execute. Something that also surprised me personally was that the QR codes were apparently not as successful because I personally believed they would be really successful.

Figure 3: Survey instrument "Future boxes"

Initially, it was quite challenging to think creatively and develop an innovative yet practical approach for designing our survey model. Naturally, the first idea that came to mind was a basic questionnaire. However, we were determined to find a more unique solution. We considered alternative methods, such as creating a Kahoot quiz or asking students to do peer interviews. Yet, we found the first option boring, and the interview approach seemed impractical, especially given the large number of students at our school.

We came up with the idea of using a sticker board for younger students. In this model, children would place stickers – each representing a particular theme – onto categories they found interesting. We initially regarded this concept pretty effective, since we assumed that younger students might be interested in topics that differ from those preferred by older students. In this system, the younger children would simply select from pre-established subcategories based on the method we intended to use with the older age groups. However, we soon recognized a major flaw in this approach: it unintentionally gave older students more influence over the younger ones' choices. This was problematic, especially since many topics that interested the older students were irrelevant or unappealing to the younger children. Consequently, we realized that using different systems for different age groups would not be fair or equitable.

At this point, we began discussing activities in which all students, regardless of age, are equally involved. This led us to consider the process of electing student representatives, particularly the use of cardboard boxes with slots. These boxes seemed like simple yet effective solution to a complex problem.

Following this realization, we focused on the layout of the papers and the specific questions to include. One point of discussion was whether we should incorporate a question solely about students' interests, independent of academic subjects like mathematics. After some deliberation, we decided to include it. In detail the questionnaire included the following questions. First page: What topics would you like to know more about? What interests you most about the topics mentioned? Second page: What topics would you like to deal with in math lessons?

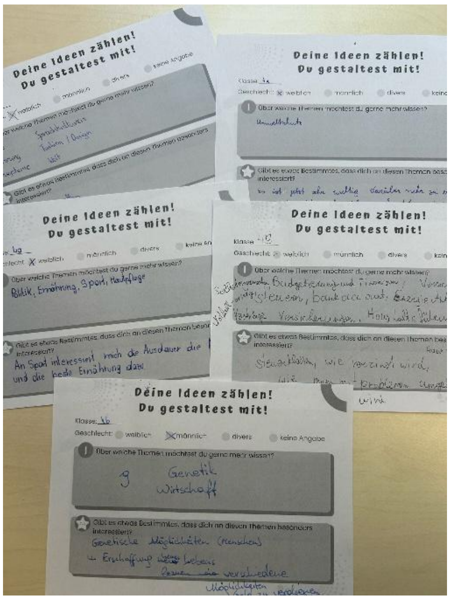

Figure 4: Questionnaire "Future boxes"

One of the first observations we made was the challenge of thinking innovatively within a highly regulated and rigid system. Most survey models tend to be variations of the same basic concept, so we were genuinely pleased when we finally developed a model that was both functional and feasible.

However, this led us to our next challenge: many of our initial ideas, although highly creative, were simply unrealistic and difficult to implement, especially for a group of students with limited resources.

Additionally, one outcome that personally surprised me was the limited success of the QR codes. I had initially assumed they would be highly effective and widely used, but the results did not meet our expectations.

Data Collection

Data collection in school- Future boxes

After a meeting with the entire class, we were divided into our groups, where we began discussing how best to present the project to the classes and determine the most effective ways to introduce and distribute the questionnaire. The sheets containing the questions, which had been formulated by leading members of the project, were handed to us so that we could rehearse our introductions and explanations.

One of the challenges we faced was ensuring that students did not turn over their paper prematurely, as the questions on the back specifically addressed the mathematics lesson. After some consideration, we devised a solution: placing the papers flat onto our "Zukunftsboxen." This approach served a dual purpose. Firstly, it prevented the students from noticing the presence of additional questions on the backside due to light shining through the paper. Secondly, it

Figure 5: Data collection with the help of "Future boxes"

helped us maintain their focus on our instructions, which was crucial for ensuring they understood the task. Additional to this, we placed the questionnaires as flatly as possible down on their desks. While this worked in most cases, some students' curiosity led them to turn over the sheets before instructed.

Another survey method we implemented in the project was group discussions. We divided the classes into small groups and assigned them popular topics derived from their questionnaires, along with specific questions they needed to answer. Initially, these questions were general, addressing their thoughts on the topic and why they had chosen it. Subsequently, the questions became more focused on mathematics, exploring how these topics could be incorporated into math lessons or whether they could envision solving problems related to them. After group discussions, a class-wide debate took place, where each group presented their results and could contribute to others' findings.

The results from classes across the school were quite different from our initial expectations. Students in grades 5 to 7, as well as some in grade 8, showed a predominant interest in topics like nature, sports, and hobbies. In contrast, students in higher grades expressed greater interest in politics, finance, history, and science. Additionally, some responses contained only mathematical topics, which could indicate that certain students either struggled to think of non-school-related subjects, were influenced by previous responses and our explanations, or had already seen the back of the questionnaire and thus had mathematics in mind when answering the first set of questions.

Due to the noticeable differences between grades 5 to 8 and grades 9 to 12, we had to rephrase certain questions for the younger students. However, this did not pose a significant challenge for the initial classes we visited, as we thoroughly explained everything in advance. In some classes, preventing students from flipping over the paper before completing the first page was difficult. We adapted by engaging them in conversation and asking additional questions while others completed the questionnaire. At first, estimating how long younger students would need to answer the questions was challenging. However, by observing their body language and providing clear instructions, this became easier as we gained more experience across different classes.

In conclusion, we gained valuable insights into the process of designing and implementing questionnaires in various formats and learned what factors need to be considered to make them appealing and easily understandable for all age groups. Additionally, we obtained a deeper understanding of which topics different age groups consider important today and how students respond when their peers ask them questions in an effort to enhance their learning experience.

Data collection in society: Flyers + Stickers

We are part of the data collection team and our task was to distribute flyers and affix stickers with QR-codes on them to collect the opinion of society. Furthermore, we went to the University of Klagenfurt where we interviewed multiple students from different age classes and diverse backgrounds.

Figure 6: Stickers placed in public

Firstly, our whole group of citizen scientists got the provided stickers and flyers from the data collection tool creators and our goal was to distribute them in Villach and elsewhere. We sticked the stickers on public places, like for example bus stations, with the aim of people scanning the QR-codes and taking part in our survey.

Unfortunately, we noticed that this plan was not very effective because not a lot of people participated. Now we have to rely on the results we get from the flyers we distributed in doctors' offices, universities, shops and so on. We also handed the flyers to people directly. Recognizably this method has greater success.

We can conclude from this that it is either necessary to address people directly or to spread more appealing and visible QR-codes. Our assumption is that not many people find the small stickers attractive enough to take their time to finish the survey completely. Our data shows us that the majority of participants started to fill out the questions, but did not complete them.

__Data collection in society: Interviews with people of the general public__

Secondly, we went to the university of Klagenfurt for one day and asked students first-hand our questions for the project. The questions were the following: Which socially relevant should be taught more in schools? How would you rank those 10 topics regarding the importance in schools? Referring to math classes, what should occur more during the lessons? What are the reasons for your opinion?

Figure 7: Interviews at the Alpe Adria University Klagenfurt

This strategy was enormously helpful and very efficient. Due to direct conversation, we were able to collect peoples' honest perspectives and could scrutinize their argumentation. The interview form is more open and provides space for a bigger variety of explanations. Additionally, we noticed that different age groups have other approaches to the topic.

We are confident that we will be able to collect enough data to get a great output of our project and to make a difference in the future for more realistic math tasks.

Data Analysis

As part of the group responsible for data analysis, we are currently in the process of reviewing the data from the Future Boxes. To begin the process, we met with Sandra Wieser and discussed the procedure. Since the Data Collection group gathered data from classes 1 to 8 (5th to 12th grade), we first divided the different grades among the members of the data analysis group. Each member read through the results of their assigned grades. Then we compared the answers and created nine main categories. This allowed us to get a general overview of the nature of the responses, and these categories were further subdivided if necessary.

The nine main categories that emerged from the data are: Finances, Politics, Inter- and Intrapersonal, Technology, Society, Health, History, Natural Science and Sports.

Furthermore, we talked about patterns we noticed and the key differences between different grades. At the end of our meeting, we split up the workload and came up with four key questions to help us extract the most valuable information to us.

- What are the differences in categorization between upper and lower grades?
- What differences do you notice between question 1, question 2 and question 3?
- What examples are there for the major categories?
- What was surprising?

The results will be collected in an Excel spreadsheet to give an overview of the data. We are currently still in the process of evaluating. The first quantitative results will be ready on April 30th, where we are going to present them to the rest of the research team including the students of 6A and 7A.

Conclusion

Although the data review process is not over jet, it is possible to talk about the challenges and learnings the students faced with during the research process. Looking at the results of the individual groups, it becomes clear that they had to deal with different challenges and therefore also followed by various learnings.

Survey instruments
The group that created the survey instruments learned that different age groups can or must be taken into account in surveys and that different target groups require different approaches. They also learned about the advantages and disadvantages of different survey tools and selected suitable tools for the study. In a social context, they have learned how to work in a group and find compromises.

The group dynamic process was particularly challenging, as was finding suitable survey instruments for the respective target groups.

Data collection
The group that collected the data first had to come to terms with the fact that the way in which the survey instruments are presented can have an influence on the results. Another learning was that different survey instruments produce different types of data. For example, the future boxes provided quantitative data, but the group interviews were very helpful and important for the quality of the data afterwards. The different reactions of the lower and upper school also showed that one's own expectations of a survey often do not materialize, which is why one must remain as objective as possible and only repeated surveys optimize the processes.

Both a learning experience and a challenge was that the stickers and flyers were not as popular as originally expected. This showed that the considerations made in advance did not produce the desired result. The personal surveys at the University of Klagenfurt, on the other hand, were very successful and provided important insights and data.

Data Analysis
One of the most important lessons learned by the data analysis group was that you need a strategy and guidelines before you can start an evaluation. As this group is still in the evaluation process, not much can be said about further learnings at the moment.

A further research question at the center of the report is which methods the students choose to collect the data. This question cannot be answered simply because not just one method was chosen. The students have made distinctions between society and school, but have also taken into account the different age groups at school. For society, the method with stickers and flyers was chosen, which they used to conduct a survey. In addition to these surveys, they also opted for traditional street interviews. At school, they opted for a multi-stage process in which they first threw initial ideas into a box and then, in a second step, interviewed individual classes in detail during group discussions.

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