

# THE ROLE OF MATHEMATICS IN STEM TEACHING ACTIVITIES

*STEM is advocated in policy and practice as an approach to ensuring interest in science, technology, engineering and mathematics, ensuring a qualified workforce in the future and even more importantly to develop responsible citizens (Bybee, 2018). In the integration of STEM disciplines there is a growing concern about the role of Mathematics – i.e. that Mathematics is isolated, falls in the background and does not get the attention it should, given the centrality of Mathematics in all science disciplines. This paper reports a study consisting of 1) the review of 4812 articles to identify STEM learning activities and 2) in-depth analyses of 37 articles, focusing on different roles Mathematics can play in integrated STEM activities. A preliminary result of the study is presented in the form of an analytical construct, which helps identify and clarify the many roles Mathematics potentially can play in integrated STEM. We propose that the construct may contribute clarity in the analysis, design and evaluation of STEM teaching and learning materials.*

*Keywords:* STEM, Mathematics, teaching

## INTRODUCTION

Currently, integrated STEM approaches receive great attention in educational research and development, and STEM can be seen as part of the solution to future challenges such as ensuring a qualified workforce and even more important to develop responsible citizens (Bybee, 2018). Mathematics is often recognized as the discipline underpinning the other disciplines, but at the same time mathematics plays an understated role in integrated STEM (Maass et. al., 2019). Answering the question *what roles does mathematics play in STEM activities as described in research literature?*, this study presents a construct which provides a framework for understanding of the different roles mathematics can play in STEM activities.

## THEORETICAL FRAMEWORK

Mathematics benefits less from the STEM-approaches as compared to the other disciplines (English, 2016). It is therefore important to make the role of mathematics transparent and explicit in designing STEM-activities. If not there is a risk that the role of mathematics will remain hidden (Shaugnessy, 2013), and according to English (2016) an inadequate focus on the connections of mathematics to the other disciplines will weaken mathematics learning within STEM activities. Maass et al. (2019) suggests three possibilities for advancing the role of mathematics in STEM approaches by connecting learning in STEM with the following: (1) the acquisition of twenty-first century skills; (2) meaningful inclusion of mathematical modelling in school education; and (3) education for responsible citizenship. Shaugnessy (2013) suggests on the other hand that STEM activities just need to involve a problem to solve and that mathematics then must contribute significantly when solving the problem. A different approach often found in the literature is that the other disciplines can act as context for enhancing the development of mathematical skills, but Fitzallen (2015) emphasizes the reciprocal relationship between mathematics and the other STEM disciplines: STEM can be seen as a context for learning mathematics, but mathematics is on the other hand also important for understanding the ideas and concepts of the other STEM disciplines.

## RESEARCH METHODS

To answer our research question, a systematic search, selection and reading of articles was conducted guided by the review procedures as described in Petticrew and Roberts (2006). The search string focused on STEM in title or abstract and with an additional, explicit search for articles containing mathematics. This resulted in finding 4812 articles. Guided by exclusion criteria and with explicit focus on clear descriptions of STEM activities, 37 articles were selected. The articles were read, analysed and summarized in a table with the four categories *activity content*, *goals of activity*, *assessment of activity* and *mathematics*. These four categories were further synthesized by the authors for every article answering the question: What role does mathematics play in the described activities? The analytical process followed, working out how to make sense of the notion of 'role of mathematics'. Based on the literature studies, a heuristic was developed, which grasps the different ways in which mathematics can interplay in STEM. This abductive process took place as a facilitated, collective sense-making exercise, centred around two whiteboards and resulted in two analytical constructs: one which seeks to describe whether mathematics is in the foreground or background in the STEM activity, and a second one which seeks to further qualify the role mathematics plays. The constructs were subsequently verified by reviewing the 37 articles using the analytical construct. In this paper we present the second construct.

## RESULTS

The construct (fig 1) contains two distinct roles for the way mathematics relates to the other disciplines. Mathematics can be applied as *a tool* in the STEM activity or mathematics can be regarded as *a specific goal*.

When mathematics is a tool in STEM activities, mathematics can be used in a problem-based course. In the literature review, examples of how mathematics is used in problem posing, understanding the problem, and solving the problem were found. In the review, it is also seen that mathematics is used in an engineering design process to enhance the process and the product. Finally, mathematics is found as a tool to develop a deeper understanding of science or technology for the students.

In the reviewed literature and examples of learning activities, mathematics can also be as *a specific goal in itself*. Here we distinguish between two types of mathematical goals namely competencies (like mathematical modelling, or reasoning competence) on the one hand and mathematical content and skills on the other (understanding concepts like numbers, statistic or geometry). In these cases, the other disciplines act as context for the learning of mathematics.

## DISCUSSION AND CONCLUSION

It will often be the case that the relationship between mathematics and the other disciplines is reciprocal and somewhat dynamic. For this reason, it is important to note that the construct is not a simple categorization device, where one learning activity only fits into one box. Often, the categorization of a STEM activity in either mathematics as a tool or mathematics as a goal will be up for discussion and specific STEM activities may well fit into more than one category. The construct, however scaffolds discussion, clarification and analyses of the different roles mathematics can have in STEM- activities. We suggest to use the construct when analyzing and discussing existing STEM activities and in the design and development of new learning activities. The construct potentially can assist educator's in building awareness that mathematics can be integrated in several ways. The construct potentially also can support ideation to develop new STEM activities, with due attention being paid to the role of Mathematics.

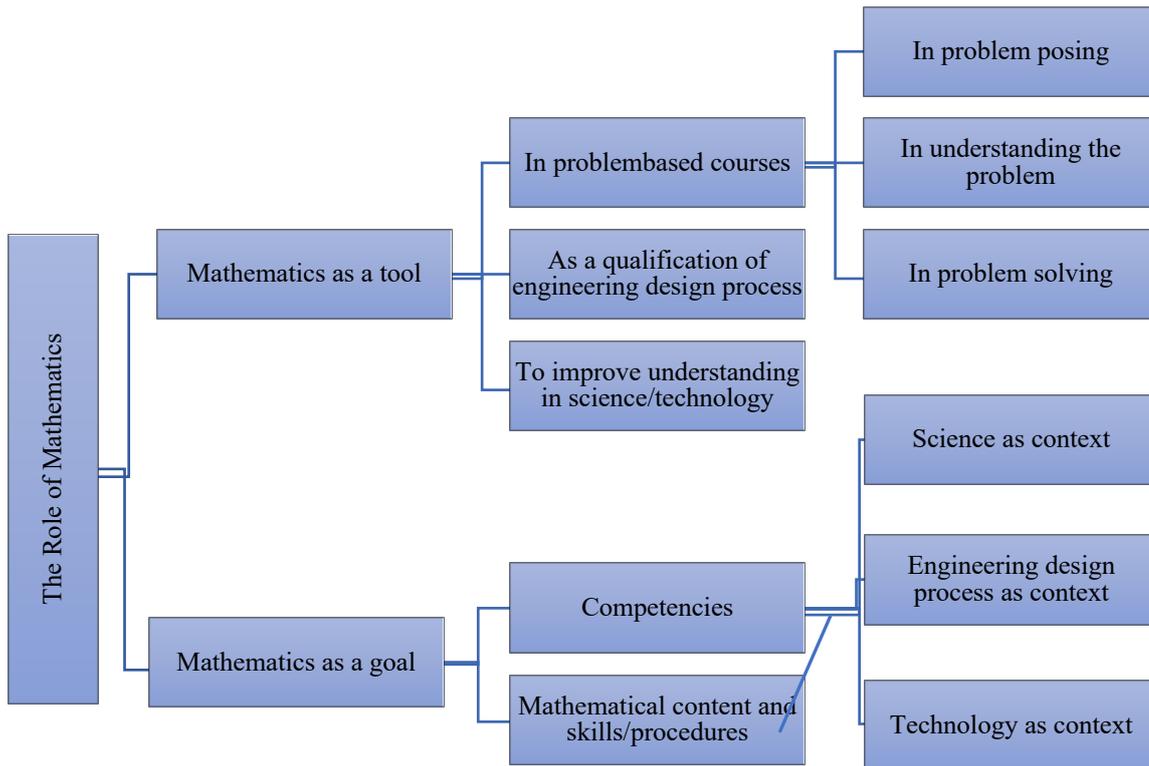


Figure 1. Construct of the role of Mathematics in STEM activities.

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