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From a teacher student's view – how STEM-actors have impact on teacher education and teaching in STEM

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Abstract

In this study, Swedish STEM-teacher students' experiences of STEM-actors are explored. 85 teacher students have visited each, of a total of 21 different STEM-actors (science centres, museums, maker spaces, code clubs etc.) who all offer school classes STEM-activities but also in-service teacher education. The teacher students were given the task of observing, interviewing and analysing. The teacher students' report texts constitute data that has been analysed thematically. In the teacher students' statements, no disputing attitude towards the STEM-actors emerge. It seems that a preconceived approach is being developed among the teacher students that the school system needs external STEM-actors for both further education and teaching in T&S. The student teachers become convinced that the formal school setting fails to make the subject of technology fun and interesting enough. Nevertheless, the student teachers are not completely convinced that doing (construction), i.e. practical work, is always what should be most important. They express the view that the teaching must contain engaging, fun and interesting elements and that it requires subject competence of the teacher. The student teachers are undergoing a teacher training course which includes encounters with STEM actors, that seem to have resulted in a view that technology teaching in a formal school setting is insufficiently interesting, engaging and fun.

Key words

STEM actors, science centres, technology teachers training, student teacher training

Introduction

In Sweden, formal education in the school system is conducted in collaboration with actors from outside the formal school system (out-of-school science environments). Science centres, different museums and other actors (e.g. various actors in programming, maker spaces etc.), referred to here as STEM actors, offer their services to actively employed teachers, both for the teachers' own continuing education and to receive school students and provide teaching in school subjects. This is not unique to Sweden. It occurs in many other countries, and researchers throughout the world have studied the similarities and differences between learning in formal and informal contexts. Some of the research has been focused on contexts, affective and social aspects, the nature of participation and the specific content (Martin, 2004; Stocklmayer, Rennie, & Gilbert, 2010; Wellington, 1990). STEM actors also collaborate with the universities' teacher training programmes by offering teaching facilities, equipment and teacher-led teaching for students who are to become preschool teachers and teachers in various subjects, such as science, mathematics and technology. Collaboration with different actors outside the school is particularly prevalent in the STEM subjects, and it has been shown to result in fruitful learning opportunities for student teachers (Avraamidou, 2014; McGinnis et al., 2012).

The reason that STEM subjects, school students, teachers and student teachers receive this attention from different actors outside the school is that school students' interest in STEM subjects is considered too low, and that stimulating teaching activities are needed which schools in the formal school system do not seem capable of providing (Adams & Gupta, 2017). The STEM actors' starting point is that they are willing and able to contribute to increased interest in STEM among children and young people. They base their activities on their own great commitment and believe that this, together with their environments and activities, leads to increased interest in learning among students of school age (Martin et al., 2016).

The teaching approach of many of the STEM actors is based largely on Dewey's ideas of "learning by doing". Sometimes the learning in question is described as multimodal, which means an environment rich in materials, models and experiments behind which phenomena and principles are concealed, which creates interest and allows for its own investigation (Rennie, 2014). At many of the STEM actors, there are also links inter alia to makerspace. This is the concept of an environment that focuses on learning rather than primarily teaching and which gives participants an opportunity to engage in a process-oriented, authentic task based on the individual's interest and commitment (Halverson & Sheridan, 2014). The maker movement originated in *the do-it-yourself movement* and gives participants access to technology, tools and materials that previously only existed for various professions (ibid.). Many STEM actors describe their operation as an environment with adaptable and practical tools that support and cultivate school students' interest in science and technology. Often, the intention of STEM actors is to interconnect formal and non-formal education, they want to address society as a whole, span multiple subject disciplines and support multiple ways of knowing and learning (Zolotonosa & Hurley, 2021).

The intention of STEM actors is thus to educate and inspire student teachers and active teachers, as well as children and school students. In addition, many of the STEM actors offer activities for children and young people during their free time, on weekends and evenings, as well as during holidays. They may also put on longer courses during holidays and at weekends. In some cases, leisure activities can involve costs for the individual child.

Evaluations and studies show that STEM actors are considered to be an untapped and important resource for active and prospective teachers (Melber & Cox-Petersen, 2005; Carvalho, 2021). Studies show inter alia that STEM actors can be of great help to both teachers and school students in teaching/learning situations when they create a wealth of both cognitive and affective activities, linked to the school students' previous experiences (Mujtaba et al., 2018).

In terms of the collaboration of science centres and other STEM actors with the school, the studies focus on the learning environment offered and its effects, in particular, the effect that the environments have on students' interest in STEM. Studies show that the actors' environments clearly present STEM as something that is fun and interesting, in which everyone can immerse themselves and find their future profession. School students feel they become motivated to learn through the activities offered by STEM actors (Lavie Alon & Tal, 2015; Bamberger & Tal, 2007). The STEM actors offer well-equipped and exciting premises, and this has also been shown to contribute to increased interest (Adams & Gupta, 2017).

At the same time, studies show that STEM actors can be very focused on visitors' feelings, interest and attitude, with the aim of increasing their self-confidence in STEM, but are significantly less focused on teaching within the subjects (Sasson, 2014).

STEM actors have a desire to reach all students; they want to act in such a way that everyone will thrive and understand what is being taught. However, research shows that the actors' intention to reach everyone could be interpreted as contributing to expectations of students that are far too low (Shaby et al., 2018). In addition, studies show that the actors' environments tend to attract certain groups and that other groups do not feel as welcome. Leisure-time visits to the environments are mostly the preserve of children and young people with well-educated parents, which means that these groups also feel at home in the environments when they visit them with their school classes (Godec, S., et al., 2022). Similarly, children and young people with highly educated parents are more likely to feel at home in the environments that are constructed on the actors' premises, such as laboratories and robotic labs. Many children of highly educated parents have heard their parents talk about similar environments, or indeed the parents have even shown them to their children. Children who lack such references may find laboratory environments to be very alien. Studies also show how the STEM actors' way of presenting their environments can also contribute to a sense of alienation in some children and young people (ibid).

STEM actors have been criticised for conducting activities that misrepresent research in science and technology, that focus on principles and phenomena rather than processes, and that take science and technology out of context without looking at inherent problems (Bradburne, 1998; Davidsson & Jakobsson, 2007). The actors have also risked being accused of presenting a normative picture of STEM, which has led to internal development and transformation projects. The purpose of the actors' development projects has been to change both the image of the actors' environments and the traditional image of STEM (the "crazy" scientist, "computer geek" etc.). In recent years, therefore, some actors have changed their way of working and their environments (Lawrence & Tinkler, 2015.). STEM actors have inter alia collaborated globally to jointly develop their operations and make themselves accessible to more target groups. They want to be an active player in teacher education and the continuing education of teachers. In particular, they highlight the aim of creating pathways to welcome school students of all backgrounds to science and technology learning and to meet them wherever they are (Zolotonosa & Hurley, 2021).

Purpose of this study and its central question

Against this background, a study has been conducted of the experiences, as related by student teachers, of various STEM actors, after the students visited the environment and interviewed educators. The aim is to investigate the impressions, experiences and perceptions aspiring teachers obtain from the encounter with STEM actors within the framework of a teacher training course. These are impressions that may colour the future role of the teacher.

The central question is the following: what emerges from student teachers' reflections about the encounter with a STEM actor?

Methods

To find an answer to the question, a case study has been conducted. A total of 85 student teachers each visited a total of 21 different actors (science centres, technology museums, open-air museums and similar actors), all of which offer leisure activities to children and young people, as well as activities related to school subjects within STEM to school classes. All actors also offer active teachers continuing education and are engaged in different ways in various teacher training courses.

The various STEM actors are spread across Sweden. The student teachers in the study are all training as subject teachers in technology, mathematics, physics or chemistry, many of them intending to teach more than one subject. Therefore, they intend to become teachers in lower secondary schools or upper secondary schools.

This specific element in their teacher training, the encounter with the STEM actor, together with the associated processing, takes up one week. Prior to the encounter with the STEM actor, the student teachers were invited to first read the following article, as a mandatory activity:

> *Eva Davisson & Anders Jacobsson (2007) Different Images of Science at Nordic Science Centers, International Journal of Science Education, 29:10, 1229-1244.*

The students' task was to observe, interview, analyse and write reflections over a total of four days and then write up an account on the fifth day. The student teachers were to participate in the operation and observe (participate in) the teaching on the first day, conduct interviews with educators and participants and compile these on the second day, study websites and other materials and analyse everything on the third day. On the fourth day, the students had time to compile all their material, conduct supplementary interviews and prepare their presentation. After that, the student teachers were to present their conclusions. Before they started with the task, the students were clearly instructed to read the article, prepare interview questions, observe, ask questions about and analyse the following:

- Who are the participants/school students? (Background, aims, gender/age etc.)
- How is the teaching/session structured?
- What learning objectives and activities are evident?
- What do the organisers want to highlight: subject knowledge, subject culture, ideals, values, gender aspects, etc.?

The student teachers were then asked to observe and possibly try to teach something themselves, all the while taking notes. The students were encouraged to have plenty of material which they could analyse, present and use to write up their own reflections on everything they had encountered.

The written reflections of the student teachers, their presentation slides and the accompanying scripts constitute the data set for this case study. The parts in which the student teachers presented their analyses and reflections constitute the primary data set, given that the purpose of the study is to gain an insight into the student teachers' impressions and experiences.

The student teachers' analyses, reflections and presentations are thus textual material that has been analysed thematically with the aim of identifying apparently important aspects of what

the student teachers want to highlight, based on their main impressions. The thematic analysis has been carried out systematically and inductively, inspired by Braun and Clarke (2008). The data set has been left to speak for itself, the text has been read and re-read before commencing on coding of the text contents. Themes have been generated by the coding and then grouped into summary main themes.

The main themes may be said to answer the central question and give a picture of the impressions emerging from the student teachers' reflections.

Results

The student teachers come away from the encounter with the STEM actors having gained an impression. This is the impression that the student teachers present and reflect on in their texts. The student teachers describe the extent to which they agree with aspects they refer to in respect of the STEM actors. The student teachers emphasise the importance of the actors for schoolchildren and teaching, but also the impressions they have gained regarding the view of the competence of active teachers and the role of the school. The impressions described by the student teachers have been compiled into the following themes.

Build up the school student into someone great

A basic assumption, discernible among the students and which they also ascribe to the STEM actors, seems to be that more individuals are needed who invest in a career in science and technology. They also believe that being well-educated in science and technology is a valuable general competence to possess. The student teachers state that the STEM actors undertake important work and that their operations are needed to help the school student achieve something great. At the STEM actors, important characteristics of human beings are highlighted, as are the kind of knowledge and competences that will be required for the future.

> *"The goal is for everyone to leave their premises a little smarter and that their curiosity is aroused." (Student statement)*

Often, the STEM actors also link valuable knowledge and abilities to sustainable development. According to the student teachers, the STEM actors emphasise many perspectives: how nature nurtures; the need for self-confidence in technology; the need for new innovators; the importance of keeping career paths in mind; the fact that research can be undertaken by ordinary people and that girls should feel that they can choose careers in STEM; the view that curiosity, commitment and creativity are important qualities, etc. These are perspectives that a majority of the student teachers emphasise in their analyses.

> *"The aim is to bring out school students' hidden abilities in science and technology. They want to show school students that science is for everyone. They want to arouse interest and develop subject knowledge in a playful way, connecting science to reality." (Student statement)*

According to the student teachers, the STEM actors want to get young people to explore the world and believe that it is important for them to develop into individuals who base statements on science and who value investigations and experiments. For the student teachers, the STEM actors thereby evince a set of important features characteristic of humanity. The student

teachers present what the educators say without directly identifying any inherent problem. For example,

> *"educators believe that boys are more interested in function while girls are more interested in design and decoration". (Student statement)*

In the case of many of the student teachers, the STEM actors' statements are presented as truths. They underline how science and technology are areas that comprise knowledge which is important for the future. Working in these areas requires certain characteristics and viewpoints. For the student teachers, there seems to be nothing problematic about this. They seem to share the same values and viewpoints that they perceive the STEM actors as presenting. Among other things, the view that career paths in science and technology are important, and that this also needs to be emphasised for school students.

> *"The inspiring environment also gives school students a clear picture of possible career paths within STEM. Scientists are also ordinary people. An ordinary person can become a scientist." (Student statement)*

Get school students to understand what is interesting and fun about STEM

The students value the fact that the STEM actors seem to apply great enthusiasm and emphasis in spelling out the importance of stimulating the school students to develop curiosity, creativity and an interest in science and technology. However, the student teachers also construe this as an indication that the school does not manage it to a sufficient extent. The students contrast the way in which the STEM actors talk about the subjects and what is important with the way the subjects are taught in school. The student teachers reflect on and seem to value the crucial importance of the STEM actors in compensating for deficiencies in the school environment. The statements of the student teachers all tend to express the same opinion. In their descriptions, the student teachers emphasise how important it is for school students to become interested and involved. According to the students, this is made possible by the environment and concept of the STEM actors.

> *"It's hard not to get involved in the task when it's so obviously interactive and conducted in a stimulating environment." (Student statement)*

A majority of the student teachers emphasise how the STEM actors take the view that school students should learn that science and technology are fun and exciting. The student teachers value the commitment of the STEM educators and their positive attitude to showing that the subjects are fun. In their presentations, the student teachers imply that it is an accepted truth that such an approach is necessary. Both the STEM actors' presentations of their operations and the student teachers' analyses convey therefore the importance of demonstrating to the school students that science and technology are fun. This can be interpreted to imply that the point of departure for the school students is that science and technology are boring and uninteresting, which is why the prevailing approach is to respond at all costs to this dullness by presenting the subjects as fun and interesting. The student teachers do not reflect critically on this, but evidence an unchallenged belief that students need to find the subjects fun. The student teachers are enthralled by the STEM actors' school programmes which, with a variety of different means, manage to present the subjects in an interesting fashion.

> *"The school programmes are designed with the aim of generating interest in science and technology. In order to arouse interest and understanding among the school students, a lot of props are used, and phenomena are explained based on different models." (Student statement)*

Provide security for insecure teachers

The student teachers are attentive to where STEM actors are coming from and clearly point out that active teachers possess insufficient competence in science and technology. However, the student teachers do not seem to feel as though this applies to them and seem to take the view that many *other* teachers lack the relevant knowledge. The view that many teachers in primary schools lack the necessary qualifications and lack knowledge in science and technology is reinforced among the student teachers by the fact that the STEM actors stress it and highlight the importance of offering continuing education to teachers. Although the student teachers do not believe that they themselves lack subject competence, they express the view that *teachers generally* have insufficient knowledge. This can relate to e.g. programming or chemistry. For the student teachers, the role of the STEM actors as providing teachers with continuing education is important. The impression is formed among the student teachers that active teachers do not really have the knowledge and competences to teach science and technology as these should be taught.

> *"It would be good if the actor could become more integrated into school education, for example, to provide teachers with continuing education." (Student statement)*

The student teachers also convey the STEM actors' position that active technology teachers who have knowledge are nevertheless not always correct in what they do, which is why the STEM actors can help in these situations too.

> *"Here they meet the school students at their level; they have put a lot of work into developing activities at the right level. The educator believes that technology teachers often design activities at levels that are a little too high." (Student statement)*

The STEM actors described their school programmes and their relationship with active teachers and teaching to the student teachers, who value the aims of the programmes. Student teachers emphasise how the school programmes should both relate to the syllabuses and be fun; they should provide opportunities and act as a support for the teacher.

> *"The connection to the school's learning objectives is not always strong, because the lessons should primarily be entertaining. But there is room for teachers to make connections themselves to the syllabus in technology." (Student statement)*

The STEM actors' descriptions of their school programmes and their application seem to reveal a view of how active teachers may view the visits, something that the student teachers take on board.

> *"The teacher gets a programme where the activity is linked to syllabuses; the teacher gets suggestions for preparatory work and follow-up work with the class. The teacher should not see the visit as simply an isolated fun way to pass the time, but as an integral part of technology teaching." (Student statement)*

Didactic foundations

The student teachers note and emphasise that the STEM actors have very well-organised activities: they do not have a lot of time available and follow well-planned arrangements. Admittedly, the STEM actors seem to want to emphasise how important it is to listen to the school students and start from their level, wishes and their experiences, but at the same time the activities are well-planned and prepared. The student teachers describe how the actors have a given plan that they follow; they have prepared materials and resources, and they work efficiently and purposefully. Their efficiency in particular is emphasised by the student teachers.

The student teachers note the didactic foundations expressed by the STEM actors, and the student teachers highlight these positively in their analyses. For example, how important it is for school students to use their entire body in the learning situation.

> *"We believe that the actor is not just a place but a way to educate yourself; you learn best when using your whole body, your mind, your hands, your feet – everything." (Student statement)*

The student teachers note the apparent importance for all STEM actors of doing, something which also seems to win over the student teachers despite some doubts about the lack of theoretical elements.

> *"The main thing was that the participants were active, learning by doing, the school students were not given any ready-made solutions; they had to explore their ideas and thoughts. We gained invaluable didactic insights. We saw how the school students were stimulated in the classroom. But there was a lot of focus on practice and too little on theory." (Student statement)*

The student teachers also state the importance of variety in teaching, as well as the characteristics of a good educator: commitment, passion, spontaneity, experience, insight into human nature and, above all, being secure in their subject knowledge.

> *"They have a set-up with practical elements and theoretical elements, and they get the classes really immersed in the subject area. One of the keys is the educator's commitment and love of their work. They do not have an educational "master plan" that they have elaborated specifically. Rather, they work somewhat spontaneously based on educational ideas, experience and an insight into human nature. However, I feel that it works very well. The idea is that it should be fun to listen. Quick responses. Get into roles. Speak dynamically. You have to be confident in your performance and in your subject knowledge." (Student statement)*

The student teachers describe how they see the STEM actors vary the pace of their presentations and how they skilfully enable visiting school students to discover the content of the subjects. The encounter with the STEM actors and their set-up impresses the student teachers and convinces them of the importance of the actors.

> *"We have been convinced of the positive effects of varying lessons and encouraging exploration by deriving as much help as possible from external actors. The educators*

> *there are competent enthusiasts who have a lot to contribute. They know how to package lessons." (Student statement)*

However, there are student teachers who are also critical to some degree of the STEM actors' didactic approach; specifically, they point out how the focus on practical activities can lack a sound theoretical foundation.

> *"We feel the actor is important in promoting an interest in technology among young people. However, we believe that the actor's teaching can be improved. The interest seems to be less pronounced in older children, and one reason may be that the practical tasks they get to try are often insufficiently rooted in theory. Children understand how an experiment can be performed but not why they get a certain result. A stronger connection to science might contribute to increased interest. Entertainment and theory do not have to be mutually exclusive." (Student statement)*

While the student teachers seem to value the entertainment value of the actors' activities, they also demand a stronger connection with the theoretical basis. In some cases, some student teachers also suspect that there may be shortcomings in the STEM actors' theoretical knowledge.

> *"In the teaching we participated in, we lacked a more comprehensive technical explanation as to why trusses are strong. Some of us who are more versed in strength theory thought that the mastery of concepts was rather lacklustre when explaining what strength and stability mean in a truss structure." (Student statement)*

Fantastic environments

It is not only the educators at the actors who impress the student teachers, but also the environments and equipment offered.

> *"Same content as school but... better equipment, better premises, more inspiring environment" (Student statement)*

> *"The actor is a fantastic resource for mainstream schools because the educator is committed and knowledgeable. The operation is characterised by high quality, great insight and strong commitment; there are lavish materials and expensive equipment." (Student statement)*

The student teachers describe how important it will be for school students to be able to encounter the STEM actors' environments. This is so they can see how different the environments are from their school classrooms where there is a lack of equipment. The STEM actors emphasise to the student teachers that they follow the school curriculum. They say that they have also created activities that can be directly linked to the syllabuses, but that they allow the school students to encounter the subject content in much more inspiring environments, with more advanced equipment, or environments and objects that are distinctive in other ways, with more lavish materials and resources. The STEM actors seem to think that their operations are a necessary complement to the school's teaching which can be implemented in a school setting, but that at the same time it is not a requirement. The student teachers describe the

STEM actors as a valuable complement to the school's teaching that does not even require commitment from the teacher.

> *"The activities are complementary to mainstream teaching, but they have modern equipment. They recommend that the teacher does some form of preparatory and follow-up work; however, it is not a requirement. Some teachers want to tick off central content, while others just think it's nice to get away."*

The student teachers also state that the STEM actors have the resources to create specifically creative, inclusive environments with the aim of attracting all school students regardless of background.

> *"The environment is inclusive; everyone regardless of background or scientific knowledge should feel at home. The important thing is not to know, but to start observing and putting into words what you see. The premises should feel pleasant and homely so that the visitor will feel comfortable and not be anxious." (Student statement)*

According to the student teachers, the attractiveness of the environments comes down to the light, colours and objects that together provide opportunities for interaction and a full sensory experience. The environments provide a high degree of multimodality. Many student teachers describe the environments as being crucial to the students becoming interested in the subjects. However, there are student teachers who point out that the STEM actor in some cases goes too far when it comes to images, sounds, colours, different materials, etc., and that school students may risk being "overstimulated".

> *"The building material consists of a predominance of colourful paper and glitter. There is also a trend towards requiring that something be happening all the time, that all senses should be stimulated at once. There is a plethora of instructions, but it seems to work well anyway." (Student statement)*

The specific technology content

The student teachers also state which specific subject content related to technology teaching is highlighted by the STEM actors. When it comes to technology teaching (which has been chosen as the focal point for this survey), the student teachers' descriptions make clear what appears to be relevant content. The basis for relevance can largely be interpreted in what the STEM actors consider to be important knowledge and relevant abilities, but also things which, in their view, active teachers fail to do because they lack sufficient knowledge or equipment. In the student teachers' reflections after encounters with different STEM actors, a number of themes emerge that recur at several different actors. The student teachers relate that, overall, the STEM actors' technology activities include the following content.

Pneumatics linked to mechanical elements

A number of actors told the student teachers how they allow school students to work on small projects in which they get to encounter pneumatics in combination with mechanical elements in their own constructions. For example, the school students may build a so-called pop-up figure that is controlled by pneumatics, or they may, using pneumatics, move a structure of their own design. Such projects are mainly aimed at school students in the 7-12 age bracket.

Strength and deflection

According to the student teachers, some actors described how school students get to encounter theories related to trusses and that they get to build trusses with e.g. so-called 4DFrame materials. School students thus seem to be given an opportunity to learn about strength and deflection when given the task of building a bridge, for instance. Such projects can be aimed at school students in the 7-16 age bracket.

Programming

Many actors seem to focus solely or primarily on programming. According to the student teachers, this can involve school students working on creating RCO alarms, programming a Microbit or Lego robots. Other common activities noted by the student teachers are CAD programming, Tinkercad in combination with laser cutters, robot building with Microbit and Strawbees, Python programming for colour coding in RGB for LEDs in imagiCharm, etc. The STEM actors describe how school students get to follow instructions, practise technical concepts, compare with images, and then evaluate their own work. According to the student teachers, many of the actors have become specialised in getting school students to encounter programming and various digital tools – with the aim of developing digital skills. Programming projects are aimed at all ages.

Innovations and creativity

The student teachers also report that many STEM actors are keen to emphasise the importance of allowing school students to work on innovations in order to develop creativity and the ability to work creatively. A common approach is that school students are given a task to develop something that already exists, but in a "different direction". According to the student teachers, the STEM actors want to focus on practical activity and creativity; they want the school student to be able to use tools, materials, etc. This bears out the premise that school students can develop knowledge about how one gets ideas and how one can develop one's creativity.

History of technology

Another common content item identified by the student teachers among the STEM actors is the history of technology perspective. It can be found not only in museums with a special focus on history but also in other actors who seem happy to reconnect with how technology has evolved and changed over the years. The student teachers note that it often relates to the development of everyday objects and different built-up environments.

Technology of the future

Just as often as actors are eager to capture historical changes, the student teachers relate that the actors want to set their sights on the future. According to the student teachers, the STEM actors talk about the importance of school students gaining insight into the new technologies of today and those of the future. The descriptions provided by the student teachers indicate that the actors are optimistic about technology, and most of the student teachers also expressed this view in their analyses. In terms of the actors' view of the future, AI, space technology and the use of robots seem to be the technologies where it would be most important to acquire the appropriate knowledge.

Specific space theme

At a number of STEM actors, the student teachers found what they interpreted as a specific focus on space. The actors seem to have chosen to relate in various ways to what is happening e.g. on Mars and as regards technology that makes space travel possible.

Sustainable development

Most student teachers noted that the STEM actors want to highlight content linked to sustainable development; the actors also see this in some way as their distinguishing characteristic. However, this aspect seems to be mainly about sorting, reuse and resource efficiency in regard to the materials used in the construction processes within their own activities. The student teachers relate how the actors explain how they encourage students to sort leftover materials for recycling and sustainability – they also relate how they let the school students use recycled materials, including ordinary things that all students can find at home. At some actors, greater attention is paid to highlighting the 2030 Global Goals. The student teachers emphasise how the goals are used as a starting point for the activities at many STEM actors. This may take the form of the way in which the problem-solving task can start in a problem related to the global goals. The school students are then encouraged to help solve the problem by building a prototype. For example, students are tasked with building a mini-power plant or solar cells, usually by following a given set of instructions.

Discussion

The purpose of this case study is to investigate what impressions, experiences and perceptions aspiring subject teachers in technology, science or mathematics obtain from the encounter with STEM actors. These are impressions, experiences and perceptions that may colour their future teaching role. The question that was asked initially is what emerges from student teachers' reflections about the encounter with a STEM actor.

Student teachers arrive at a view of STEM actors as a valuable complement to school-based teaching in science and technology, which is a common view in research into science and technology teaching (Adams & Gupta, 2017; Melber & Cox-Petersen, 2005; Carvalho, 2021). The student teachers argue in favour of the actors' environments and their equipment, but also their teaching methods and commitment. This is something that has also emerged in previous studies, and which has proven fruitful for school students' learning (Lavie Alon & Tal, 2015; Bamberger & Tal, 2007). A majority of the student teachers state that they share the view of the STEM actors' aims in the latter's operations, that teaching should generate interest and curiosity and should lead to more young people being interested in career paths in science and technology. This is an approach that is clearly present among STEM actors, and which is also borne out in larger societal contexts (Zolotonosa & Hurley, 2021). The student teachers also value the STEM actors' continuing education for teachers, not necessarily for themselves but for colleagues who lack subject knowledge. The student teachers' statements rarely evince a critical attitude towards the STEM actors and their various operations; it becomes clear that the underlying views and values are shared. The STEM environments are appreciated by the student teachers; this is also borne out in other studies (Avraamidou, 2014; McGinnis et al., 2012).

Focusing in particular on the teaching in technology, the following is evident. In the student teachers' descriptions, one can detect a view of the school's formal teaching in technology as

being insufficient to arouse school students' interest in the subject. They see active technology teachers as lacking the skills to show how much fun technology is and to create commitment. They view the schools as lacking in satisfactory equipment. This is a viewpoint confirmed in previous studies (Adams & Gupta, 2017). The specific technology content presented by the actors is not significantly different from that taught in a formal school setting. Many schools have access to both teaching materials and equipment that direct the teaching specifically to pneumatics, mechanisms and programming. Common elements of schools' technology teaching are a history of technology perspective and space themes in terms of looking to the future. Work on developing technology with innovative elements and a lot of hands-on construction is also common in schools' technology teaching. The technology content offered by the STEM actors is thus in itself nothing new or remarkable, as the student teachers also note. Admittedly, there are more materials and equipment, but the technology content itself is nothing spectacular. Regarding the technology content, there is even some criticism among the student teachers about e.g. the lack of theoretical elements. However, one thing is borne out by the student teachers despite everything: the student teachers' analyses find it self-evidently important (and this is also confirmed by the STEM actors) that school students should receive teaching in technology that is *fun*. The basic assumption that school students must encounter technology teaching that is fun if they are to become interested seems to be already strong among the student teachers; but it is also further reinforced by the STEM actors. Among future technology teachers there is thus the belief that school students find technology teaching boring; this may be seen as a basic assumption that risks becoming entrenched further.

The reflections of the student teachers after the encounter with the STEM actors can be summarised as follows. The student teachers do not seem to think that they themselves lack subject competence. However, they become convinced that the formal school setting fails to make the subject of technology fun and interesting enough. The student teachers are not completely convinced that doing (construction), i.e. practical work, is always what should be most important. Rather, they see shortcomings in theoretical foundations as problematic and suspect that there is an excessive reliance on materials and equipment. Nevertheless, they come down strongly in favour of the view that the teaching must contain engaging, fun and interesting elements and that it requires subject competence of the teacher. The student teachers are undergoing a teacher training course which includes encounters with STEM actors as one of its elements. The encounters may be said to have resulted in a view that technology teaching in a formal school setting is insufficiently interesting, engaging and fun. They themselves look forward with great confidence to teaching technology and they seem to want to make use of the STEM actors' environments and their commitment.

It became clearly that both STEM-actors and the student teachers themselves strives for to reach and give all young people the opportunity to get involved and interested in STEM. Earlier research (for example Archer et al, 2022) describes how interest and motivation for STEM among young people is strongly related to their culture capital (specific STEM capital). That is debated with relation to Bourdieu's theories about habitus and capital (for example Bourdieu, 1986). In relation to such theories and results, both how STEM-actors choose to organize their activities and how student teachers habitus give strategies within STEM, could be opportunities for further research. Likewise, it could be interesting to study if there is a difference in 'impressions' between student teachers with a specialism in science or mathematics rather than technology.

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