Chapter

An Exploration of Guide's Roles in STEM Outreach Activities: A Contribution to Students' Motivation for Career Aspirations?

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Abstract

This explorative study investigated guide's behavior and actions who had an active role in STEM-based (science, technology, engineering, and mathematics) outreach activities in secondary education. In outreach activities, schools and teachers work together with companies and other external institutions in learning activities to motivate students for the STEM domain. In these outreach activities, guides "taught" from a teacher's perspective and at the same time "were a role model" from an ambassador perspective. To observe guides behavior in two different activities, an observation instrument was constructed using both perspectives by conceptualizing a need-supportive behavior with a focus on effective and metacognitive outcomes for students, based on the self-determination theory. In this chapter, our findings and instrument will be described.

Keywords: STEM, outreach, secondary education

1. Introduction

Subjects in science, technology, engineering, and mathematics (STEM) are getting more attention in secondary education, industry, society, and policymaking. From an economical perspective, both knowledge and innovation capacities of (future) employees are key to growth in a sustainable manner [1]. In addition, to meet the sustainability goals set by the United Nations for 2030 [2, 3], technology, knowledge, and innovation are highly needed. This means, on the one hand, a demand for the number of STEM-based jobs and on the other hand an overall understanding of STEM-related topics for all citizens [4].

As known from former studies, fewer students are interested to pursue a STEM-related career [1, 5]. One of the possible factors for not being interested in a science career might lie in school science itself, as it does not always offer students the full picture of what to become and what impact STEM subjects have in daily life (e.g., [1, 6, 7]). In Ref. [8] it is stated, for example, that it is important to show students the connections between different subjects. This gives the students the opportunity to see the relevance and the use of STEM in everyday life [9].

A possible solution to contribute to filling the gap between school science and science as part of society is outreach activities provided by parties outside school, such as companies and higher education institutes. As outreach is a widely used concept, for this study, outreach activities were characterized by three main aspects: 1. active participation of a STEM-based company or higher education institute; 2. guidance during the activity is provided by the company or institute; and 3. a connection is made between school science and the real world of STEM [10]. The main objectives of these activities are about showing context, ways of working, and all kinds of technical possibilities within the world of STEM beyond school science [10]. Therefore, students can see and experience the impact of several STEM applications, and what kind of skills are needed to work in the STEM field. Sometimes, these activities are executed in an out-of-school environment, without grading and subjects of outreach activities, and were mainly context-based. Therefore, these activities can also be seen as structured informal learning environments [11, 12].

Within these activities, the guide appeared a key player, as the person who was organizing and "teaching" the activities and therefore might have an impact on outreach activity characteristics. In our former studies [10, 13, 14], from a student perspective, outreach activities appeared to be promising add-ons for science courses from a motivational and future career preparation point of view. In prior studies, about outreach activities, mostly university outreach programs with students or faculty members as STEM-ambassadors were investigated, in which the providers (i.e., students and faculty members) were trained in communication and content [15]. In other programs, faculty members were trained to educate content to secondary school teachers, to enable the teachers to provide the content [16]. In our study, the key player (guide) was an experienced expert in a STEM profession from industry and used this perspective from which the guide informed students about science content and the (commercial) work environment. The main objective was to inspire and inform students about STEM. STEM teachers are usually not fully aware of current STEM practices in companies and STEM career possibilities or may even have stereotyped career ideas. Hence, company-based STEM ambassadors might fill the gap and can provide career information to inspire students and to show STEM practices possibly enhancing students' enthusiasm and confidence for STEM [17, 18]. Therefore, we propose that the guides' activities can be seen as falling within a combination of two different roles. First, the guide—to a certain extent—acts as a teacher. This role comprises various sub-roles described by various authors [19], of which the sub-roles of content expert, learning facilitator, and possibly "catalyst for change" seem the most relevant for the coach. From this role, guides could also potentially contribute to (twenty-first century) skills that may be important, such as adaptability, complex communications, nonroutine problem-solving, self-management, and systems-thinking [20], as these skills are important in companies to stay in business. Second, guides can be seen as STEM ambassadors; that is, the guide is the personification of the company, their expertise or products, and the way of working [6]. He also represents science careers more generally. In this respect, the guide provides an "exemplary face to the abstract idea or possibility pursuing a science career" and can be a role model for students to identify the career opportunities [21]. Activities within this role may comprise demonstrating the relevance of science in that context, showing and talking about career possibilities, etc. In both these roles (i.e., teacher and ambassador), guides are expected to contribute to the intrinsic motivation of students and to students' awareness of the impact of STEM and willingness to engage in STEM-related future careers. More specifically, using SDT motivation theory,

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motivation is assumed to come forth from addressing students' needs for competence, autonomy, and relatedness [22]. As the role of guides in outreach activities has not yet been specifically defined by the field and has not been studied from these two roles yet, this will be an explorative study to investigate guides' behavior during outreach activities from both roles and their added value for students' autonomous motivation.

2. Conceptual framework

In our conceptual framework [13] based on the self-determination theory (SDT), we stated that the outreach learning environment is assumed to be a motivational environment, wherein students' basic needs are satisfied to a certain level (**Figure 1**).

The outreach learning environment differs from a regular school learning environment with respect to tasks, subjects, objectives, locations, context, and the way the guide is organizing and teaching and can be seen as authentic, as the context of STEM determines the task. And the main objective does have focus on exposing students to the meaning of STEM outside school and encouraging students to consider a STEM career. As guides are not responsible for curriculum aspects, such as grading or other cognitive learning outcomes, therefore, motivational, attitudinal, and meta-cognitive outcomes [23] are of interest. The authentic tasks and topics are based on the actual work guides do in their daily life. Therefore, the role of the guides is different and special compared to a teacher's role: The guides in these activities will perform activities from both a teacher's perspective and a STEM-ambassador perspective. In these outreach activities, guides "taught" from a teacher's perspective and at the same time from a STEM ambassadors' perspective. To map guides' behavior and actions, the exploration in this study focused on their activities in the teacher role and/or STEM-ambassador role, which is expected to contribute to creating autonomous motivation based on our previous studies based on self-reported student perceptions [10, 13, 14]. In addition, observational studies exploring, for example, autonomy-supportive teacher behavior are limited and have only been applied to regular educational practices [24–26]. In the next sections, we will define and operationalize observational need satisfaction dimensions from both a teacher perspective and a STEM-ambassador perspective, based on the literature, to create an observation instrument and explore guides' contributions to student motivation for STEM. This instrument is based on the three basic needs based on SDT. All indicators described in the next sections might enhance or frustrate need satisfaction.

2.1 The perspective of the guide as a teacher

2.1.1 Competence support

We confirmed in our former study [13] that students' perceptions of personal relevance in outreach activities were positively associated with autonomous motivation

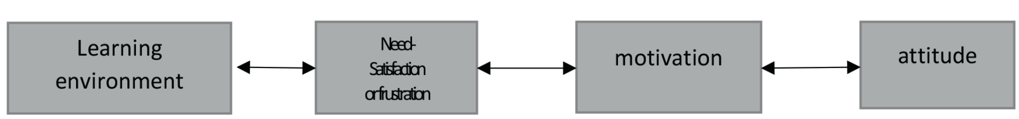

Figure 1.
Conceptual framework.

and negatively associated with controlled motivation. Therefore, the content is characterized by the *relevance*, and it is key for the competence support how guides give examples of *the relevance of their content knowledge and applications in relation to the curriculum*. To enhance learning about STEM, the science curriculum must include connections to the usefulness of abstract content in daily life including the restrictions of real-world applications [6, 12]. Therefore, guides *must shape the activity* by including explanations of complex real-world examples and *relate these* in a logical way to the idealized situations currently taught in the regular curriculum. To support students' feelings of competence further, guides *can provide positive feedback* and clear objectives [27]. In addition, working with and learning about real-life applications connected to students' (school) knowledge can enhance feelings of competence even further as the relevance of STEM is emphasized. Thus, from a teacher's perspective, relevant indicators are a) what typical curriculum domains are used and how these subjects are connected, b) showing the relevance of the curriculum and the connection of the field of guides' expertise to the school curriculum, c) the way the guide structures the activity with a clear objective (i.e., understanding STEM), and d) the way the guide is providing feedback.

2.1.2 Autonomy support

In the study [28], autonomy-supportive (teacher) behavior was positively correlated with students' autonomy-support perceptions, such as offering encouragement, time for student talking, teaching methods giving students the opportunity to make their own decision (*experience practice*), and avoiding controlling language, such as "must" or "have to." This will increase students' involvement. To support students' feelings of autonomy, even more, guides can give them a *rationale for* why they need to know certain content and can take student's perspective [27, 29]. This rationale might be given when a guide is using a *variety of typical curriculum* domains and making the connection between those domains with the context they work with (i.e., *richness*). When a guide is able to connect the context with the impact on students-every-day life, which is connected to students' personal interests, the feelings of autonomy might enhance.

2.1.3 Relatedness

Relational supportive behavior is part of the affective domain, where connections between guides and students are important. As the objective is to show students the possible skills needed for STEM-related jobs, fostering self-insight as part of the activity can be shown by caring, showing respect, enthusiasm, and being responsive to students [22, 30]. The knowledge of the curriculum content that is intertwined with knowledge of how students think about, know, or learn STEM content, and knowledge of the curriculum and content and teaching are assumed to be important for fostering autonomous motivation (i.e., PCK-model) [31]. This means that guides can address students' needs when students are asking questions during the activity, for example, being enthusiastic and encouraging students during activities [28]. In outreach activities, guides do not have an educational training, but mostly they have experience "on the job" and are well motivated to connect to students. Therefore, it is interesting how *guides respond to student questions* about content and the realistic examples shown. Finally, having students experience success and praising them, accordingly, are the important indicators for guides' behavior.

2.2 The perspective of the guide as a STEM ambassador

2.2.1 Competence

Also from an ambassador's perspective, guides might give students positive feedback to enhance students' feelings of competence, by using students' comments that advance the conversation and offering some extra advice during the activity [26]. From the perspective of a STEM or company representative, guides might include explanations of the complexity of real-world examples compared with ideal situations and the presence of more uncertainties and uncontrollable variables. Also, guides might show that how to use science knowledge is determined by social, cultural, and economic values as they are the content experts of applications in STEM. Connections to the company or society that are overtly made, making it easier for students to understand the topics better. Thus, guides who facilitate this border crossing and relevance might enhance students' feelings of competence [12]. Therefore, from the ambassadors' perspective, the structure of the activity will be determined by a work context and thematic based.

2.2.2 Autonomy support

Ratelle et al. [32] stated that autonomy support of adults other than teachers (in our study guides) might contribute to students' motivational resources. In addition, an autonomous supportive guide might compensate students for consequences of the negative effects of a controlling school environment. The expertise of the guide is bringing innovation in terms of authentic examples and context, and, therefore, contributes to the rationale of doing science courses in school. In addition, if guides emphasize value and impact of STEM, showing students that working in STEM gives them the possibility to shape the future and contribute to society in terms of health, happiness, and safety, this will promote confidence and will contribute to the need for competence and autonomy [17, 18]. Therefore, it is interesting to see what authentic contexts were mentioned by guides in relation to STEM, their STEM-based company, the impact of guides' work in STEM on society, and career possibilities (working with others). This can give students the possibility to reconnect their competencies with practical settings and satisfy their need for autonomy [12, 26, 28, 33].

2.2.3 Relatedness

Identifying with professionals helps students to develop a career identity and satisfy the need for relatedness if guides are non-directive and cooperative toward the student. To encourage learning and enthusiasm for STEM, guides might respond to students by sharing their sense of wonder and reflective storytelling, using a combination of facts and emotions [17]. Guides can share their personal interests in STEM and their career choice, and therefore might be a role model. As found by [34], working in collaboration with guides, students in informal settings described their guides as sharing identities. Using the way of working typical at the workplace, using student language to explain, encourage students asking questions, will satisfy the need relatedness. It might be interesting to observe how guides use these aspects during an activity.

Table 1 gives an overview of our conceptualization in terms of indicators of guides' behavior from both perspectives as described in these sections. Guides' might

Motivational need	Indicators	Specified indicators guide as a teacher	Guide as an ambassador
Competence	Objective & structure	• Understanding as objective mentioned and appropriate for the structure of the activity? • Linking activity to (several) curriculum domain(s)	-Interest as objective or showing new views of science and scientists as objective mentioned, and appropriate for the structure of the activity? -Linking activity to a specific company-based context or theme
	Relevance	• Relating content of the activity to curriculum. Connecting concepts to everyday experiences	-Relating the content to daily work and/or societal issues
	Feedback	• Providing positive feedback • for example, well done, good job, very good answer • using students' comments • offering students guidelines or advice to proceed	
Autonomy	Richness & rationale	• Variety of curriculum domains are used, and connected • Explaining the impact of the content for every-day life • Taking student perspective by using students' own phrases and ideas	• Authentic contexts used in relation to STEM or the STEM-based company • Explaining the impact of guides' work on society • Mentioning career possibilities
	Experience practice	• Offering students decision-making opportunities	• Giving the opportunity to experience various authentic tasks
relatedness	Communication	• Enthusiasm about STEM • Encouraging students	• Enthusiasm about his or her work/company and/or in relation to STEM • Encouraging students to proceed in STEM
		• Giving students experiences of success • Putting effort and energy in the activity, demonstrating commitment	
	Collaboration	• Trying to understand and interpret students' questions about concepts	• Trying to understand and interpret students' questions about applications and working in STEM (career-related issues)

Table 1.
Categorization scheme of guides' behavior and actions by basic needs, indicators of needs, and specified indicators for each need.

support students' feelings of competence, autonomy, and relatedness on the one hand, but can also undermine these feelings on the other hand, if they do not connect to student needs.

3. Research question

We observed the role of guides in two different outreach activities (workshop and guest lesson), to analyze to what extent guides contributed to the possible need satisfaction of participating students. Ideally, guides can meet all the needs (i.e., competence, autonomy, and relatedness), with an emphasis on the relevance of the meaning of STEM, and with a clear but distinct way of school science, without a disconnect from school science. On the other hand, it is interesting to observe to what extent guides also undermine students' need satisfaction, by ignoring or depriving certain needs. Therefore, we combined previous data on these activities about perceived student motivation and related factors, such as activity characteristics, with additional data (observations and activity description documents by companies) to generate detailed and in-depth portraits of guides active in two different outreach activities. This helps us to answer the following research question:

What kind of behaviors of guides in two different outreach activities can be observed in terms of autonomy, competence, and relatedness support or undermining?

4. Method

Two activities were selected in the study, where were both representative for the outreach study and could be videotaped without any constraints on safety and technicalities. The activities had a fundamentally different setup and nature, including the role of the guide. The first activity was a workshop ("research-day"). About one hundred students (9–11 grade, N = 105) went to a STEM-based company for a couple of hours to experience *via* several workshops what kind of applications this company was working with. One representative video-taped workshop was analyzed. The other activity was a guest lesson about making liquid crystal displays (LCD) taught by the guide in school for several classes (8–9 grade, N = 86). Four out of six lessons were videotaped, and one lesson was analyzed. Both companies and students were informed about the video-taped observations and asked for permission to use these observations for research purposes only.

In our former studies perceptions of students', teachers and guides of the outreach learning environment were mapped. For both activities, teachers' perceptions were most positive compared to students' and guides perceptions. The workshop learning environment was perceived more positive by students compared to the guides, especially for the personal relevance, uncertainty, innovation, and autonomy support. Both students and guides had comparable perceptions of the guest lesson learning environment. Descriptions of the activities in company documents were used to reveal the intended objective, expectations, and role descriptions. Additional information about the perceived objective was asked for in a questionnaire for students. Also, during the activity, the objective as mentioned by the guides was observed. To determine observable activities of guides, we used indicators as conceptualized in **Table 1**.

4.1 Activities

Guides in two representative activities (a workshop and a guest-lesson) were observed. **Table 2** shows the characteristics and descriptions of these two activities.

4.2 Analyses

The video-taped activities were analyzed using the indicators, based on SDT according to **Table 1**. Each activity was observed several times and coded according to the indicators. After analyzing the separate observed activities, the results

	Activity:	
Characteristic	**Workshop "the piezo-electrical effect"**	**Guest-lesson liquid crystal displays (LCD)**
Teaching method	Three-hour workshops in groups of 6–8 students. Each group was able to attend two different workshops. No teacher presence.	Lecture-based, with interactive experiments. Teacher or teacher assistant present.
Objective	To influence students for choosing STEM-courses in high school by showing "the fun and unexpected aspects of technology" (source company report). Guides do so by explaining their subject.	New views of STEM and scientists
Context	Company-based	Company-based
Location	Out-of-school, partly with own classmates in a STEM-based company (R&D department)	In-school, in their own classroom
Selection	Yes, some of the students were selected by their teacher.	no
Frequency	Every year for schools in the area	Schools can book the activity every year.
development	Guides from the company with advice from teachers	Guides from the company with advice from teachers
guidance	2 guides per group (Alfred and Jacob), most of the time no presence of the teacher. Both guides had some former experience, but no educational background or additional training.	2 guides were present, one as the main presenter, the other to help with the experiment and the materials and both told something about their background in STEM.
Main structure	Science concepts were explained and used in one of the applications of both the company and daily life, and students were allowed to use company devices and examples of applications during the workshops. The workshop was based on the application of the piezo-electrical element (source: company description of activity and observations).	Explanation of the concept, the experiment and explanation of applications. In this lesson, these components alternated during the whole lesson.

Table 2.
Activity characteristics of selected and video-taped activities.

were combined with other data sources in a data display matrix to make an overview of the main results per data source for each guide. The focus of this matrix was to provide structured input for a portrait description of the role of the guide and his/her effect on students. Guide portraits were developed structured in two main components: background (based on descriptions, mapped perceptions, and observations) and behavior (based on observations). Finally, a cross-case analysis was conducted by systematically comparing the two guides with each other to find patterns. The two guide roles were compared by using both the data display and the portraits. The reliability of the questionnaires (used to map the perceptions) was established in our former studies. The use of representative quotes from interviews and examples from video observations also supports the reliability of our portrait analysis [34].

5. Results

What kind of behaviors of guides in two different outreach activities can be observed in terms of autonomy, competence, and relatedness support or undermining?

5.1 Alfred and Jacob (Workshop)

Students' perceptions of the objective of this activity showed that 17% of the students thought that they learned just some other STEM topic, and 37% of the students thought it was to show them some new STEM applications, 18% it was for career counseling, and almost 25% did not know or thought it was to interest them. The guides did not mention an overall objective. A short description of the structure of the activity can be found in **Table 2**.

5.2 Competence supportive behavior

5.2.1 Objective and structure

At the start of the workshop, Alfred started with the explanation of how to do research: "doing research starts with understanding how things work." And he used reversed engineering by demolishing a simple gas lighter, so students should find the piezo-electrical element. During the explanation of the science behind this piezo-electrical element, many concepts were mentioned in only 8 minutes. As mentioned by Alfred as: "I figured out you need a small crash-course about chemistry first, to understand this application." During the second part of the activity, a second guide, Jacob, joined the workshop. They were changing roles constantly: One of them explained and the other assisted, although Alfred did most of the explanations. All concepts explained were linked to both the chemistry and physics curriculum, and were used in a context-based approach. This context approach together with the density of concepts was relatively new to students. Therefore, both Alfred and Jacob were challenged to stay on page with the students. For example, at the end of the piezo-electrical effect workshop, a student asked "why do you need this material anyway (i.e., piezo-electrical material)" and this student did not realize that this material was needed due to restrictions mentioned by Alfred in the second part of the activity, and therefore was the essence of the workshop.

Alfred's' behavior as seen from the teacher role was undermining students' feelings of competence. He tried to explain too many concepts in a relatively short timeslot, resulting in several storylines that were not always easy to understand in full by students. On the other hand, Alfred and Jacob used a theme (i.e., piezo-electric material) to connect all the activities and therefore, the activity was well-structured, and the structure of the workshop fitted the objective of the activity.

5.2.2 Relevance

During the workshop, many examples for the use of a piezo-electrical element were mentioned and demonstrated by Alfred, such as a post card with music, electrical guitar, and other examples from students' daily life. In the last part of the activity, both Alfred and Jacob explained about more complex-company applications (i.e., nebulizer and catheter), with the same material within the healthcare domain. Although the connections between curriculum concepts with everyday experiences and contexts were made, the link with daily work was not mentioned. Alfred did mention that when you are working at a company, just understanding how certain material works is not enough, you have to make something with it "That is interesting, but what can we do with this (i.e., piezo electrical material)? What is the practical use? We are working at a company….."

5.2.3 Providing (positive) feedback

This way of doing research was new for students. For the initial question "who knows where the flame originates from," students answers were not correct. Alfred's feedback was: "that it is a good explanation but not applicable for these…." Students were constantly encouraged during this hands-on activity to try and find the element they were looking for, by giving advice. Also, when asking questions Alfred encouraged students to answer and gave positive feedback when students tried to answer these questions. "Very good answer" and "can you come up with all possible differences between these objects, just start." Despite this positive attitude, the amount of time for students to think was limited.

Table 3 gives an overview of all need supportive or undermining guide behavior.

5.3 Autonomy supportive behavior

5.3.1 Richness and rationale

Alfred started with an example close from the daily life of the students (gas lighter). During the experiment, students were free to join, interact, and choose how to proceed. Next, Alfred explained concepts needed for understanding the element he wanted to focus on. This was a thematic approach, and as a result, the concepts were connected. Alfred verified regularly if students knew certain concepts. For example: "who knows what an ion is?" Later on, examples of work and company-applications were mentioned. Alfred explained what the company works on (i.e., crystal structure of a piezo-electrical material): "we did research on this material in our group." And why this is important: "we work at a company, so what is the practical use of this material?" Both the ultrasound and the nebulizer in the healthcare domain were mentioned as important products, and Jacob explained in general terms that this was his work. He did not work in a group doing research at this material, but in a group were micro-technologists' work. "Our main objective is to make things small and energy-efficient (in the healthcare domain)." Although both the impact of the applications (a nebulizer for people with cystic fibrosis) and the work and challenges were mentioned by Alfred, the interaction between students and Alfred was less frequent than in the first part of the activity and the reaction of Alfred to answers of students turned into a more controlling wording, without using students' input of ideas.

Motivational need	Indicators	Specified indicators guide as a teacher	Guide as an ambassador
Competence	Objective & structure	• Explanation of a concept and its applications fitted the structure of the activity • Several links with curriculum domains were made, sometimes too difficult for students	• The theme was clear
	Relevance	• The content was connected to the theme, but too many storylines • Several everyday examples were given	• No direct links with work were mentioned, but the use of a characteristic material in the perspective of a company was clearly mentioned
	Feedback	• Alfred used only general positive feedback, such as "well-done" or "good job."	
Autonomy	Richness & rationale	• A wide variety of concepts was mentioned, the connection was not always clear to students. • The use of the material in every-day life was given • Taking student perspective not observed	• Many authentic contexts were mentioned. • The impact of applications guides worked on was clear • No career possibilities were mentioned
	Experience practice	• Students were free to join and pick a way of working during the experiment	• The start of the activity was an example of how guides usually work
relatedness	Communication	• Enthusiasm about STEM • Encouraging students during experiment	
		• Giving students experiences of success during the experiment • Putting effort and energy in the activity	
	Collaboration	• Trying to understand students' questions, but not verifying if an answer was sufficient	

Table 3.
Specified descriptions of guide's behavior and action for all needs.

5.3.2 Experience practice

The experiment Alfred started with was derived from the way of working used in his daily work. During the workshop, Alfred let the students work together in small groups using re-engineering as an example of a common way of working in a STEM-based company to understand how things are working and how to improve these. Jacob (the second guide) joined the workshop as well, which was also an example of how people in a STEM-based company work together. During explaining concepts and contexts, one of them explained and the other demonstrated. Although this activity took place at the facility of the STEM-based company, the students were in a small room, and the workshop could have been provided at any location. **Table 3** gives an overview of all need supportive and undermining behavior.

5.4 Relatedness supportive behavior

5.4.1 Communication

Both Alfred and Jacob put a lot of effort and energy to show a diversity of examples, such as playing a guitar and showing the postcard with music (and demolish it to show the element in it). Joking: “we can do this; the company made some profits last year” as an indication of showing their work culture. When Alfred was explaining he was very enthusiastic, and as a result students reacted positively, with laughter and interest. In addition, Alfred told something about his personal life: He used an electrical fence to get rid of cats in his backyard he did not like. Students reacted as they found it a bit cruel. Later, he told something about the group he worked in and what kind of project he was involved. Furthermore, he encouraged students during the experiment to figure out themselves how to proceed, and let the students experience success when they found the little piezo-material. In addition, when he explained that what they were doing was re-engineering, a girl reacted: “I have three brothers who are in engineering.” Alfred’s reaction: “now it is your turn” as an indication of showing interest in the student and encouragement.

5.4.2 Collaboration

When Alfred asked a question (about STEM and applications), he encouraged students to come up with some answers and always reacted positively: “good answer,” but did not rephrase any of the answers nor checked if students were satisfied or understood the answer. Despite his enthusiasm, Alfred was not always able to connect and be on the same level of the students.

Table 3 gives an overview of all need supportive and undermining behavior.

5.5 Fred and Anna (Guest lesson)

In this activity, students had to make a one-pixel liquid crystal display as an illustration of liquid crystal display (LCD)material. Overall, students’ perceptions of the objective of this activity made *via* a questionnaire showed that 17% of the students thought it was to interest them, 14% thought it was to inform them, 42% to learn something or doing an experiment, and 25% of the students thought it was meant to be just some other content and learning about STEM.

5.6 Competence supportive behavior

5.6.1 Objective and structure

At the start of the guest lesson, Fred told they were representatives from an organization that had the main goal to connect technology with youth. Later, Anna mentioned they worked for a specific STEM-based company, but they were not present to promote this company. Fred was giving the objective: “We work as engineers ..... and we hope we can give you an impression of what working in engineering means, so you have some extra information for your future...and the choices you are going to make for your courses in your senior years of high school.” One of his questions was: “who knows already what kind of profession you are thinking of?” (a lot of students responded with a variety of possibilities, including STEM careers). During the lesson though, students were learning about concepts, such as polymers and liquid crystals, and applications of LCD's in between students worked on a small (sheet-guided) experiment. During the experiment, both Anna and Fred walked around to provide materials and to answer questions. The waiting time needed for this experiment was used to explain the next step of the making process.

5.6.2 Relevance

The theme of the lesson was LCD, and the concepts mentioned by the guide were not part of the curriculum for this age group. Only the concept of polymers is part of the curriculum in senior courses. Several analogies were used to connect to the curriculum. For example, mixing oil and water and say something about transparency. Many daily examples of polymerization were described (i.e., the fillings dentists use), and Fred used previous experiences teaching this guest lesson: "I also learned an example from some other students during a former lesson: you are doing something somewhere and keep it under blue light and it hardens" Student: "ah nail polish!" Fred: "So it is not only a theoretical story, someone discovered something, but you will come this across any were."

5.6.3 Providing (positive) feedback

Although most of the lesson time (two third) was filled with explaining concepts, applications, and the experiment, Fred and Anna asked questions throughout the lesson during the explanations, such as: "Who knows…?, Anyone playing hockey? And what kind of stick are you using? Can you come up with even more possibilities? I know it is hard." After student answers, Fred's and Anna's reaction was in general positive, such as: "very well, good job." Student contributions to the discussions were welcomed but were not employed to advance the discussion. At the end: "it is nice to see that they (LCD) work with many people. So, points for you, very well done!"

5.7 Autonomy supportive behavior

5.7.1 Richness and rationale

During the introduction, Fred told the students: "this lesson is about an experiment, and you do not have to be prepared for this nor will be tested." In addition, Fred said that they wanted to introduce some engineering to students to show what it entails to support students' future choices, but also "It is ok if you think this is not for me. That's fine." Two main concepts were used by Fred, which were just partly curriculum content. Although content about polymers students might not be familiar with yet part of this domain will be explained in senior courses. Other concepts will not be explained in high school courses at all. Therefore, the activity subject was an authentic context, LCD, what is used by Fred's and Anna's company in a variety of applications. Although not all applications were made by the company, many examples from students' daily life were touched upon, to show the variety and the impact of LCD in real life. In addition, Fred explained all aspects of LCD, how it worked, all sorts of application, and parts of the production and why the production took place in another country. "the factory is about eight soccer fields." Despite the authentic context and the connection with the company, Fred did explain just in generalities about his job: "I have worked on several things, including LCD's. It was just one of his jobs within the company."

5.7.2 Experience practice

The lesson was indicated by Fred as an interactive experiment. The students had a guided description of the experiment, and it was an illustration what Fred and Anna just explained. In addition, it was also a model to show that students had to work precisely and clean. During the experiment, students had to figure out themselves on what side of the glass the conductive layer was. Fred and Anna did not check if students had found the right side, only helped students who had questions. Anna

Motivational need	Indicators	Specified indicators guide as a teacher	Guide as an ambassador
Competence	Objective & structure	• Some links with curriculum domains were made, that were not yet familiar for students	• Some STEM applications with the objective to interest students shown. The activity was mainly about concepts, the structure did not fit completely with objective. • The theme was clear
	Relevance	• The content was connected to the theme • Several everyday examples were given	• Thinking about applications not developed yet. • Use of a characteristic mate-rial in the perspective of a company
	Feedback	• Only general positive feedback given, such as well done or good job. In addition, all students complimented at the end of the activity.	
Autonomy	Richness & rationale	• A small number of cur-riculum domains were mentioned, and some topics were not part of the curriculum. • The use of the material in every-day life was given. • Taking student perspective was not observed.	• Many authentic contexts were mentioned. • The impact of applications guides worked on was clear. • No career possibilities were mentioned.
	Experience practice	• Although it was a guided experiment, students were free to pick a way of working during the experiment.	• No opportunity for authentic tasks or daily work aspects
relatedness	Communication	• -Enthusiasm about STEM • Encouraging students during experiment	• Guides were enthusiastic about their work
		• Giving students experiences of success • Putting effort and energy in the activity	
	Collaboration	• Trying to understand students' questions, but did not verify if an answer was sufficient	

Table 4.
Specified descriptions of guide's behavior and action for all needs for the guest-lesson.

indicated that it was important to brainstorm about more possibilities and also showed an application that was not yet developed: "who can come up with an example that does not exist at this time?."

5.8 Relatedness supportive behavior

5.8.1 Communication

Fred encouraged students to think about their choices for the future, that it is important and made clear this is one of the possibilities for their future of many out there. Fred did explain why he choose for his studies and what he liked about electrical engineering (i.e., visiting science centers). Anna told something about her own choices, and that she liked engineering and the human side of it (she worked with human interfaces daily). "Especially for the girls, do not think that engineering is only for nerds. Yes, they exist, but I work in engineering as well and I do not consider myself as a nerd. Actually, I am an engineer."

5.8.2 Collaboration

Although both Fred and Anna took time after asking questions to students, and encouraged students to come with their answers, they hardly rephrased any of the answers to try to understand what students meant. One conversation about two different bullet proof vests (as an example of plastic use) was about arguments why certain products were the way they are. **Table 4** gives an overview of all need supportive and undermining behavior.

6. Conclusion and discussion

In our view, the findings have given some interesting insights into not only the need supportive behavior of guides during outreach activities, but also the need frustration. This might be of general value for recruiting and training guides for outreach activities, and to enhance students' attitude toward STEM and considering pursuing a possible career in STEM by fulfilling students' basic needs during outreach activities, which makes STEM-education more versatile.

First, we were able to construct an observation framework by conceptualizing need supportive behavior of guides (i.e., guest teachers, without any educational background) for activities with a focus on affective and metacognitive outcomes. Concerning the framework, we can conclude that it enabled us to describe need supportive or undermining guide behavior and actions. This framework might be used on forehand to provide guidance for guides who want to develop or optimize an outreach activity and enhance their provision of need support.

Second, for both activities observed, guides supported all needs, although some behaviors also undermined them at the same time. For example, showing relevance might help students on the one hand and frustrate their needs on the other hand as guides might overdo the number of examples. From a teacher perspective, some co-creation with teachers might help. Overall, guides were successful from an ambassador perspective, by adding several aspects of personal relevance and impact of applications on daily life, as such outreach activities might contribute to enhancement of students' autonomous motivation for STEM. Nevertheless, some aspects of guide behavior still need attention. For example, feedback might be more focused, students' remarks can be taken up to include in and boost the discussion, thus rewarding the students' comments. Interaction between guide and student can be increased, and care should be taken not to introduce too many concepts as to foster the need of competence (Reeve, 2016). In addition, clarity about the objective that suited the structure of the activity was not in all cases observed, which might undermine the feelings of competence. It is important for guides to be clear in what the objective of an activity is and also check it not only with students, but also with their teachers. According to SDT theory, clarity and autonomy supportive behavior will lead to higher autonomous motivation among the students [35].

Third, although in both activities guides took an ambassador role, just generalities were told about the company work, STEM, or interest of a company and no career possibilities were shown. Personal stories were shared about why guides were interested in STEM-based work. For example, by telling something about personal use of STEM, or by their educational background. In addition, they put a lot of effort, energy, and enthusiasm in the activity, but did not always connect to the students or understood what students asked. The need for relatedness might be undermined for some students [26].

Fourth, guides strongly emphasized relevance and rationale, both from a company perspective and a science perspective. Both relevance and rationale are important to satisfy the need for autonomy, if this fits the structure of the activity and students believe it is meaningful for them [35]. Both relevance and rationale were present, but the complexity of the contexts might be too much for students who are insecure or sensitive for interaction with guides [14].

Finally, the outreach learning environments showed several aspects of a context-based learning environment, according to a vision that looks at science from societal situational perspectives [36]. In these activities, both themes or contexts and relevance were leading. Students were introduced to realistic science aspects, although cognitive outcomes were not the main objective, rather affective, (i.e., valuing relevance) and meta-cognitive (i.e., challenging students to reflect on future possibilities). This emphasis is also the main challenge in outreach activities, and as guides used specific complex concepts to show the possibilities of STEM, students still needed to have a sense of understanding. In this explorative study, only two activities were investigated, with an explorative framework. We used our framework for two activities to explore guides' behavior and construct the portraits of guides. To elaborate and generalize this framework, more activities need to be mapped with our observation scheme to refine some of the categories. More details from students and guides are needed to analyze an activity in-depth. Interview data from both students and guides can help validating the observational framework. These can shed more light on the connection between school curriculum and activities. In this study, we investigated guides' behavior in specific outreach activities. Although we tried to create a complete list of need-supportive indicators, there might be more behaviors during activities that emphasize motivation for STEM that we did not include. Therefore, more activities might be mapped with this instrument. In addition, the instrument might be used for new guides in outreach to prepare and to create more awareness for supportive motivational behavior. As a result, this instrument might be used in the context of professional development to assist guides and teachers in becoming more aware of aspects that might be critical to enhance students' autonomous motivation [28]. The outreach learning environment is unique and authentic and has several aspects of context-based education. These aspects seemed to be potential in enhancing students' autonomous motivation and their attitudes toward implications of STEM in daily life. Therefore, it is important to explore outreach activities more in depth.

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