How Does School Lesson Design Contribute to Girls' Perception of Their Future-Readiness for STEM Majors? – An Empirical Study Using Critical Incidents Technique

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***Abstract*—Women remain underrepresented in Science, Technology, Engineering and Math (STEM) majors and STEM professions until today. Various studies have shown that the perception of STEM subjects among young girls, and female middle and high school students is strongly influenced by the way STEM subjects are taught in school. When designing a teaching concept, there are various perspectives involved – requirements expressed by teachers, school boards, teachers' associations, the ministry of education, parents etc. In contrast, this paper takes a less common perspective stemming from the competencies required for a successful STEM study progress and how they can be developed by an adequate school lesson design. Based on the data from a study with 777 female high school students in Germany, it is discussed which methodological approaches to teaching STEM subjects motivate them and how these approaches match the later-required competencies to start and pursue a career path in STEM.**

***Keywords*—STEM subjects, women in STEM, school lesson design, competency-based education**

I. Introduction

To fight the underrepresentation of women in STEM majors and professions, the perception of these subjects among young girls needs to be changed during their school career already. It is a common problem that girls often lack self-confidence for taking up a STEM-course of study and that they are not aware of the extent to how well their individual competencies already match the universities' requirements. They tend to underestimate their own capabilities in STEM subjects [1]. One starting point is to check what incidents during school lessons can enhance this awareness and therefore increase self-esteem.

To learn more about their experiences and attitudes towards STEM lessons in school, a study was conducted using an online questionnaire using a reputable online panel which focuses on kids and teens. A total amount of 777 data sets were collected from girls aged between 16 and 20 years. A central part of the questionnaire queried critical incidents (524 in total), with negative incidents slightly outweighing the positive ones (274 versus 250). The reported incidents were grouped into trigger categories using the methodology of critical incident suggested by Flanagan [2]. Most of the events mentioned were classified into the categories "Teacher personality and motivation" (194) and "School lesson design" (112). Regarding this fact, listening to how students perceive these categories impact their self-perceptions and competency development would be a good alternative to "constructing" it only from teachers' associations or administrative educational institutions' point of view.

This paper focuses on the way that STEM lessons are perceived by the girls and compares their positive experiences (gained via the critical incidents method) to a competency-based model stating what student beginners in STEM courses need from the universities' perspective. Since a teacher's personality cannot easily be influenced or changed by teaching methods and may be perceived very differently by different pupils, this paper uses only the incidents generally related to "school lesson design", allowing for easier application of the findings on future lessons design. By contrasting high school students with first-year students and finding out about the gaps between perceived competencies that schools can provide and those expected by professors, useful hints for school lesson methodology can be derived. So, the research question addressed is: In which way does the school lesson design contribute to the acquisition of competencies required for successfully starting a major in a STEM subject?

II. Related Work

A. Competency-Based Education

In the last years, many education institutes adopted a Competency-Based Education (CBE) in teaching and education. CBE denotes an educational approach that emphasizes the acquisition of specific skills and knowledge required in the particular field. Competencies

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are those qualities a person must possess to execute their job, role, or tasks in an effective way [3]. In contrast to traditional educational assignments, students have to demonstrate that they master these skills and that they are capable to complete the tasks assigned to them at the required level of competency [4, 5]. Competencies can be developed through education, training, and work experience, and can be broadly categorized into two types: technical competencies and behavioral competencies.

CBE is nowadays widespread in STEM education. In 2020, the Association for Computing Machinery (ACM) and IEEE Computer Society (IEEE-CS) presented the Computing Curricula 2020 with curricula guidelines for undergraduate programs in computer science, computer engineering, information systems, and further related majors. The Computing Curricula 2020 puts the focus on the competencies required and addresses the transition from knowledge-based learning to competency-based learning [3].

Malhotra *et al.* [5] argued that CBE had several advantages compared with traditional knowledge-based approaches. CBE promotes lifelong learning, encourages a self-determined and integrative learning culture, and supports students with timely and individual feedback. Moreover, it implements teaching approaches that are tailored to the requirements and goals of the students. Last but not least, CBE emphasizes transparency and articulates clear expectations and therefore has become a common approach in education.

B. *Competencies for Successful Entry into STEM Majors*

According to the observations by Thurner *et al.* [6] and Zehetmeier *et al.* [7], only about a third of the students starting a STEM major met the study requirements easily. Their research aimed at better understanding the gap between actual and required competencies. Such an understanding would allow supporting students in closing identified gaps, for example, by offering preparatory courses for the missing skills. To this extent, Thurner *et al.* [6] developed a competence model with 27 base competencies for software related study programs. A competency denotes “those cognitive abilities and skills that individuals either already possess or are able to learn, and which enable them to solve specific problems” (p. 1070). Moreover, there must be the willingness and the ability to employ a skill in variable situations.

This model covers different types of competencies [6], which are depicted in Fig. 1. First, it includes self-competencies such as self-organization or the ability to reflect. Second, it comprises practical and cognitive competencies, i.e., skills that determine how a student thinks and acts in a learning or working process. Examples are the ability to act systematically and methodically, or to express oneself clearly in written and oral form. Third, it includes social competencies such as communication skills or the ability to work in a team. Fourth, the competence model consists of technical competencies involving practical and cognitive aspects.

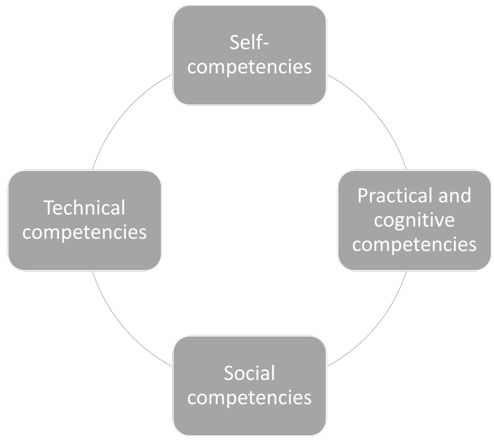

Figure 1. Types of competencies according to Thurner *et al.* [6].

Zehetmeier *et al.* [7] built upon these base competencies and transformed them in a model of 18 pairs of competencies that were complementary to each other. The model is designed in a way that students can do a self-assessment. The self-assessment results in a value for each required skill on a scale between 1 (little skills in this area) to 4 (highly developed competency). Zehetmeier *et al.* [7] moreover defined a “model student” with a certain competence level in each base competence that corresponds to the level they expected them to have as first-year student. This provides a set of base competencies with an initial level for a successful entry into computer science or information systems and management.

C. *Girls’ Perception of Their Competencies Regarding STEM*

In most countries worldwide, women are still underrepresented in STEM majors. Much research deals with analyzing the factors that lead to a low interest of female students in STEM subjects and in consequence, measures are designed to positively influence girls’ attitude towards STEM subjects. Different disciplines are involved in these research activities, such as sociology, psychology, or biology, resulting in a substantial body of literature [8].

A central problem is that girls seem to lose their interest in STEM subjects along their path through primary, secondary, and higher education [9]. This phenomenon is heavily influenced by how they perceive their own competencies and abilities and their STEM identity [10, 11]. Various studies in the last 30 years have shown that girls tend to underestimate their competencies with respect to mathematical and technical subjects [12]. In settings dominated by traditional role patterns, this underestimation is already present in the girls’ parental home where parents evaluate the STEM competencies of their children differently. While boys’ competencies in STEM are overestimated, girls’ abilities are underestimated [13]. The resulting lack of confidence intensifies problems like feeling out of place in STEM classes, the low number of girls in STEM classes and a lack of female role models [14].

As school lesson design has a considerable impact on the girls' perception of STEM subjects [15], this paper explores the question how school lesson design contributes to their perception regarding specific competencies required for a successful STEM major.

III. Research Methodology

This study analyzes the data from a survey conducted in May 2022 in Germany among female students mainly between 16 and 20 years [16]. Based on an online questionnaire, the girls' motivations, experiences, and expectations with regard to STEM subjects as well as a possible aspiration of a higher education degree in a STEM major were gathered. The questionnaire consisted of qualitative and quantitative questions. This paper focuses on qualitative data obtained, primarily on the so-called critical incidents. This technique dates to Flanagan [2] and allows to collect and analyze incidents which influenced girls' attitude towards STEM subjects in a positive or negative way. The qualitative approach allows to explore the girls' issues related to the decision for or against a study and career path in STEM as well as to generate new knowledge that can be used to encourage them.

A. Characteristics of the Data Set

The questionnaire was distributed to girls in all federal states of Germany with the help of a reputable market research panel. In total, 777 female students finalized the questionnaire. 70% of them stated their general interest in STEM subjects. Table I gives an overview of the participants.

TABLE I. Participants of the Study

Age	Percentage
16 years or younger	23.4%
17 years old	15%
18 years old	29.3%
19 years old	14.6%
20 years or older	17.8%

Table II shows the degree aspired by the female students.

TABLE II. Aspired Degree

Degree	Percentage
A-Levels	83%
Advanced technical college entrance qualification	7.6%
Secondary school certificate	9.3%

Steffen *et al.* [15] systematically analyzed these critical incidents described by the participants. The female students reported in total 524 different critical incidents which influenced their attitude towards STEM subjects in a positive or a negative way. Three researchers categorized these critical incidents independently from each other until independent seven categories emerged:

(1) Teacher personality and motivation;
(2) School lesson design;
(3) Student's experience;
(4) Student's perception of their own ability;
(5) Personal perception of STEM;
(6) Influence of personal environment;
(7) Influence of (social) media.

This paper focuses on critical incidents in the category school lesson design. Almost a quarter of the critical incidents (21.4%) gathered in the study are related to the school lesson design, i.e., the critical incidents refer to the methodology, the didactics, and the way how content is explained and presented in the school lessons. The category contains in total 112 incidents, 63 positives (56.3%) and 49 negatives (43.8%). Steffen *et al.* [15] further analyzed the critical incidents and extracted the aspects that triggered the memorable positive or negative event regarding the school lesson design. Apart from the school lesson design, the analysis of the critical incidents has shown that a teacher's own self-efficacy and personality has a great influence on the interest and motivation of the high school students towards the taught subject. Although it is sometimes difficult to separate personal character traits and habits from general methodological and pedagogical procedures, the following analysis uses only statements focusing more on the way the lesson is designed than on individual character traits of the respective teacher, therefore allowing an easier generalization and transfer of insights.

In this paper, the focus is on a certain aspect included in the critical incidents reported by female students. Fig. 2 illustrates which critical incidents were analyzed.

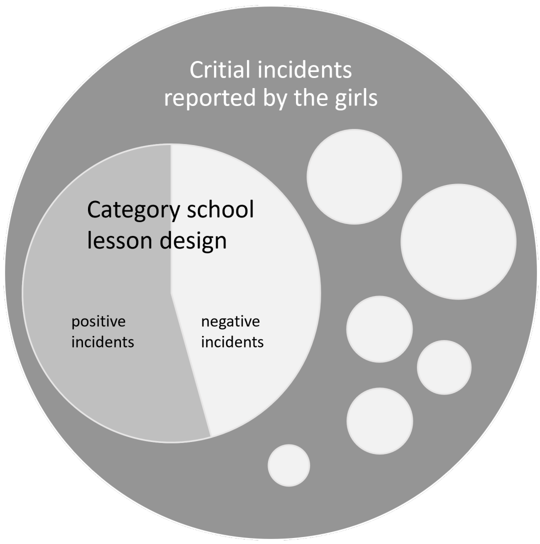

Figure 2. Focus on the positive incidents in the category school lesson design.

From the participants' subjective viewpoint, the positive incidents in the category school lesson design describe situations in STEM classes, in which the school lesson design supported the student to acquire certain competencies that are required to understand STEM subjects and to successfully start a major in a STEM subject.

B. Deductive Category Application

The positive incidents from the category school lesson design are categorized with respect to the competency that was developed or established by a specific school lesson design. A deductive approach according to Mayring was used in the sense that the categories as well as the coding rules were pre-defined based on the theoretical background derived from the literature analysis [17]. The categories serve as a foundation to structure and interpret critical incidents.

1) Categories and coding rules

In the following, the competencies described by Zehetmeier *et al.* [7] were used as categories (see Section II.*B*). They offer the advantage that they are well-defined and have already been used in various studies with students, also in self-assessments. We considered as categories those competencies that have at least a required skill level of 1 for the model first-year university student. Moreover, we added the competency "inventive" to the categories because in today's rapidly changing world, it is important that already first-year students have the ability to come up with solutions to newly emerging problems. This led to a set of 27 categories. Although this is quite a high number of categories, we decided not to cluster them in super-categories to ensure comparability with the model student.

According to the methodology for a deductive category application by Mayring [17], coding rules were developed. They describe precisely under which circumstances a certain aspect within the reported incident can be assigned to a competency category. Table III presents the categories and the rules established for assigning the incidents reported by the girls to the categories.

TABLE III. CATEGORIES FOR QUALITATIVE CONTENT ANALYSIS

Category	Coding rules
Self-Organized	Students plan the necessary steps and subtasks for a given task on their own and implement them.
Accurate	Students place high emphasis on precision, pay attention to details and double-check important aspects to avoid making mistakes.
Focused	Students can work focused on a certain task or knowledge area. They are aware of the goal that should be achieved and concentrate on this goal. A focused student is proactive in seeking out help when needed.
Self-Disciplined	Students are used to work continuously and focused on their tasks and take the responsibility for completing their tasks. They avoid distractions.
Perseverant	Students work on a topic or a subject for a longer period of time. They do not give up easily and make an effort to achieve their goals, even when faced with difficulties. They are motivated by their passion for their studies and their desire to succeed.
Intrinsically motivated	Students are driven by their own internal interests and desires, rather than external factors such as grades or rewards. They are inspired and interested in a topic to such an extent that they are eager to learn more about it.
Willing to follow instructions	Students are following given instructions. They take the time to understand them and carefully follow them to avoid mistakes, e.g., to do an experiment in a defined way.
Self-Critical	Students are consistently evaluating their own performance and are open to constructive feedback. They identify areas for improvement and seek out opportunities to learn and better themselves. They are not afraid to admit when they have made mistakes.
Reliable	Students take their studies seriously. They show up to classes on time and are prepared for each session with necessary materials. They are able to meet deadlines for assignments, projects, and exams.
Reflected	Students take the time to think critically and deeply about their learning experiences. They are open-minded and willing to consider different perspectives and approaches.
Able to take a decision	Students possess the ability to evaluate different options and make choices based on their goals, values, and available information.
Scrutinizing	Students are careful and thorough in their observations and evaluations. They are skeptical of information and claims, and they seek to verify and validate evidence before accepting it as true.
Systematic	Students can approach their tasks in a methodological and organized manner. They apply well known methods and work the assigned tasks in a structured and comprehensible way, e.g., by keeping records and taking notes.
Inventive	Students are creative, perform experiments themselves and try out different possible solutions and techniques. They generate new and original ideas or solutions to problems.
Logically thinking	Students have the ability to analyze problems or situations in a rational way. They use reason and evidence to form and evaluate arguments.
Thinking in an abstract way	Students understand underlying principles from theory, general laws and principles. They are able to generalize from concrete examples.
Thinking concretely	Students learn with the help of concrete examples and concrete practical applications. They consider the practical realities of the world around them. They can approach problems with a practical mindset, seeking out solutions that are both effective and efficient
Analytic	Students are able to break down a subject or situation into smaller parts to gain a deeper understanding of it, often through observation and interpretation.
Thinking holistically	Students are able to think on a meta-level.
Able to read	Students are able to grasp key points from texts.
Able to understand graphics	Students are able to grasp key statements presented in graphics and diagrams and to interpret them.
Able to write	Students are able to present information and results in a written form.
Able to visualize	Students are able to visualize information or results in an appropriate way.
Eloquent	Students are able to present topics which they are familiar with, to explain concepts verbally and to discuss their ideas.
Auditory perceptive	Students can grasp key points from presentations and lessons as well as understand explanations.
Self-Contained	Students are independent, self-reliant, and able to function effectively on their own. They do not require external validation or approval to succeed.
Team-Oriented	Students are able to work in teams. They value collaboration and are committed to working effectively with others to achieve common goals.

2) Category assignment

Each critical incident was assigned a category with respect to the rules shown in the previous table. If the text in the critical incident covered different STEM subjects or more than one statement, the text was split so that each aspect could be treated separately. Two different researchers performed the categorization. Another researcher assessed deviations between the category groupings, making the final decision. The percentage of agreement for the placement into categories was 89.5%. In addition to this, Perreault and Leigh's reliability index Ir [18] was calculated, which according to Gremler [19] is more precise than the percentage of agreement because it also considers the number of categories. Perreault and Leigh's [18] inter-rater reliability was 94.6% whereas Muñoz-Leiva *et al.* [20] state that values above 75% are considered acceptable.

IV. RESULTS

Table IV shows the extent to which the girls report positive experiences regarding acquiring the base competencies required for studying STEM. It is noticeable that on the one hand, there are few categories with very many elements (e.g., intrinsically motivated, auditory perceptive, thinking concretely), on the other hand, many categories contain only few or even no elements at all.

TABLE IV. NUMBER OF INCIDENTS PER CATEGORY

Category	# incidents
Intrinsically motivated	29
Auditory perceptive	22
Inventive	17
Thinking concretely	16
Focused	4
Self-Organized	4
Perseverant	3
Able to write	2
Self-Disciplined	1
Willing to follow instructions	1
Reflected	1
Thinking in an abstract way	1
Eloquent	1
Team-Oriented	1
Able to take a decision	0
Accurate	0
Reliable	0
Self-Critical	0
Scrutinizing	0
Systematic	0
Logically thinking	0
Analytic	0
Thinking holistically	0
Able to read	0
Able to understand graphics	0
Able to visualize	0
Self-Contained	0

A. Competencies Addressed in the Reported Incidents

The following competencies were the five top-most reported in the incidents. Note that the examples are literal translations of the incidents from German to English, reflecting the girls' writing style and choice of words.

1) Intrinsically motivated

Many high school students describe in their positive critical incidents' events such as certain experiments or experiences that reinforced their intrinsic motivation. They often describe that the teachers' motivation and enthusiasm for the subject has inspired them as well. In this sense, teachers are important role models for the students. Girls also often report that they enjoy the subject a lot and have fun doing exercises and experiments.

Examples for incidents in this category are:

- #176: Friendly math teachers who were extremely good at explaining and also enjoyed the subject themselves and transported this to the students.
- #772: Not a specific event, but the math lessons for the last two years because it's fun when you understand it. I was proud and happy.

2) Auditory perceptive

Girls report many incidents in this category. The high number of incidents within this category suggests that students possess the ability to grasp and comprehend the spoken words describing the concepts. However, positive incidents also emphasize the importance of teacher's comprehension and communication skills. This competency is not only trained in classical classroom teaching styles but also by using other teaching materials such as videos.

Examples for incidents are:

- #609: Positive: Teacher explained it in a funny way with good mnemonics.
- #612: I am a big fan of biology classes. Our teacher is great at conveying the content and often reinforces the topics afterwards with learning videos. The subject is so much fun and motivating because of the way she teaches.
- #662: In a situation a few weeks ago, I felt very motivated when my bio teacher said to the class we should rather listen and later (through online platforms) copy the script. Now I can better catch up.

3) Inventive

This is also one of the most-often found categories. The girls felt inventive for instance, when they could watch experiments carried out by the teacher. They demonstrated creative independent thinking, exploring the context and finding solutions on their own, without having to follow instructions or steps in certain order.

Examples are:

- #380: At school, we were allowed to dissect a lung in the biology subject while discussing the respiratory system. Everyone had a lot of fun in the lesson, and we were able to remember the processes much better. This was one of the best biology lessons and I would like to see more practical work in this subject.
- #885: As a student, I made up tests in physics for my classmates, because I understood the subject so well.
- #929: My computer science teacher had us write code on our own. We had a goal to reach, but we

had to solve every little thing ourselves. It was great!

4) *Thinking concretely*

In the incidents in this category, students report on situations in which they learned with the help of real-world examples and often in a practice-oriented way. Girls appreciate in these school lessons that the theory is conveyed in an illustrative and comprehensible manner. These seem to be very important and memorable experiences as many girls report them (14 incidents).

Examples for incidents in this category are:

- #291: [...] She incorporated everyday things into the lessons that made them much more interesting. [...]
- #675: When we did a lot of experiments in class, I was always happy about the practical part, because you could learn something from the experiment yourself.
- #1097: When carrying out experiments, as here the direct reference to reality is made.

5) *Focused*

Only few girls report on teachers who design their lessons in a way that they learn to work focused on a certain topic or knowledge area. Positive examples are teachers who support students to work on a new topic by combining different methods in an appropriate way. They provide theoretical input as teacher, show videos, do experiments by themselves, encourage students to do practical experiments and complete the subject with oral presentations given by the students.

Examples are:

- #34: Positive: interesting topic addressed, always watched a movie beforehand. Research in class. Presentations on topics
- #1144: Math tournament at school, was fun.

B. *Competencies not or only Rarely Mentioned in the Reported Incidents*

There are several categories to which only few or no critical incident at all could be assigned. This does not permit the conclusion that the school lesson design does not support the development of these competencies but only that the female students might not consider them as formative or that the acquired competency was not mentioned explicitly enough to be properly categorized.

However, competencies such as self-disciplined, self-organized, eloquent, able to write, and perseverant are considered very important by universities when compared with the model student by Zehetmeier *et al.* [7]. So, it is indeed problematic that girls do not have these aspects in mind. Only one girl reported an incident in which the teacher explicitly supported her in developing self-discipline in addition to self-organization. This teacher gives students the freedom to work on their tasks outside the classroom. She described the situation as follows:

- #802: My math teacher in middle school had a particularly positive influence on me. She always gave me extra tasks with real-life relevance as soon as I was faster or let me continue working independently. If I wanted, I was also allowed to go out and teach myself or continue working when she explained something.

V. Discussion of the Results

Looking at the categories identified and matched to the critical incidents, a noticeable imbalance becomes apparent. Some categories show up a significant number of times like “intrinsically motivated” (29), “auditory perceptive” (22), “inventive” (18), or “thinking concretely” (14). One of the common aspects that appeared quite often within these incidents was how the teacher managed to do something successfully. For instance, if a teacher manages to capture the students’ attention, they will be more concentrated. Moreover, offering experiments triggers being inventive.

On the other hand, for many competencies, there are very few or no incidents reported. One might ask whether or not those are recognized or perceived important by the students. For example, the girls mainly reported on experiments in chemistry and biology or coding in computer science, therefore focusing on learning content. However, they did not mention methodological requirements like doing project work, which is considered a powerful didactic tool in competency-based education [21]. Also, partner work or teamwork was not a topic. It seems that only the subject of the activities was memorized, not the learning methods in special or organizational aspects. Dyulgerova and Atanasova [21], however, point out that, despite the fact that project-based learning strategies have been known for a long time, teachers are hesitant to implement them in the classroom.

All in all, three different kinds of “gaps” were observed between the competency profiles provided by school and the universities’ expectancies. Fig. 3 shows the three gaps in comparison.

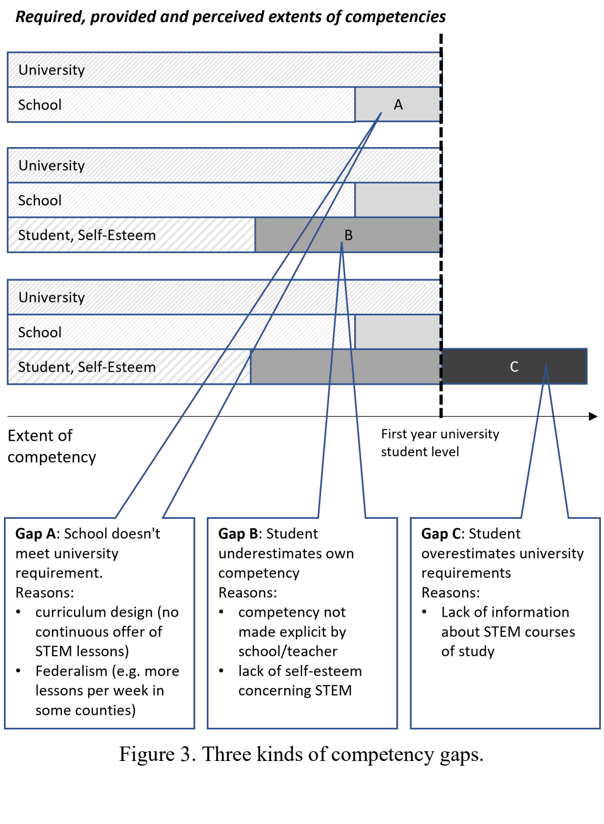

Figure 3. Three kinds of competency gaps.

1) Gap A: School doesn't meet university requirement

This gap is caused because schools do not prepare the high school students sufficiently concerning a certain competency required for first year university students such as working in a systematic way or thinking logically [7]. In consequence, the universities' expectancies are not met. The reasons for this need further investigations. The discrepancy might stem from the curriculum design itself (in some German counties STEM-subjects are not taught all through lower, middle, and senior school) or other educational boundary conditions like more or less lessons per week depending on the school type or geographic region (for an overview, see [22]).

2) Gap B: Student underestimates own competency

This gap results from an underestimation of one's own competency by a high school student, either because there is a common low self-esteem concerning STEM-knowledge or because the teachers did not emphasize on the significance of competency – for example if students do partner- or teamwork but are not aware that this also builds up their communication skills.

3) Gap C: Student overestimates university requirements

This gap is rather a deception instead of a real gap, since girls tend to over-estimate the competencies needed for successfully studying STEM-subjects. This can be traced back to a distorted image of STEM courses transported by universities or schools which leaves the girls fearful of not being able to fulfill the expectations. In a recent study, girls were asked if they felt well-prepared by school for studying a STEM subject [23]. Regarding computer science, only 16.2% stated they felt well-equipped with necessary knowledge (engineering 14%, physics 19.2%).

All three kinds of gaps can occur simultaneously and for different reasons. It is important to distinguish between the three types since the countermeasures to reduce them need to be very different – either by compensating a real deficiency (A) or by providing necessary information (B and C).

A further important aspect is continuity. When analyzing the incidents, it is noticeable that girls often report about events that happened several school years ago and how that affected their attitude towards STEM or how they pursued the respective subject or certain topics since then. Students should have the opportunity to build up knowledge and technical competences in a certain area continuously over the course of several school years and not only sporadically because of randomly occurring individual events [24].

VI. Conclusion

This paper analyzed data collected from 777 female German high school students aged mainly between 16 and 20. A total of 63 detailed descriptions of positive critical incidents were divided into single statements, categorized, and matched against a competency profile expected of first year university students in computer science and STEM courses of studies. The competencies most often perceived by the high school students were those of being "intrinsically motivated", "auditory perceptive", "inventive", or "thinking concretely", whereas others seemed not to be noticeable or not at all realized.

Some limitations must be considered: The study collected data only from Germany and the students' age ranged mainly from 16 to 20 years – a phase between puberty and early adulthood where self-esteem and self-perception change and develop rapidly. The question asking for critical incidents was placed close to the end of the questionnaire, so the preceding questions might have primed the associated incidents. While this does not affect the validity of the observations and associated competency category, this could have affected the competencies not perceived to small extent. For this paper, only the positive incidents mentioned were considered. Therefore, it would be interesting to analyze the negative ones as well.

The critical incidents described also had in common, that most of the positive answers were connected to single events like building a rocket, taking part in a math championship, or doing experiments in chemistry, thus referring to and focusing on concrete practical experiences. In contrast, negative answers often stated general attitudes and feelings towards STEM lessons like perceiving them as boring, the grades in general as being unfair etc.

Future work should address a holistic analysis of all incidents mentioned which might result in more insights on how "not to design" school lessons to avoid leaving out important competencies. Another approach could be to inform the students about what universities will expect of them and, how and why these competencies are being developed during the lessons and then ask the girls for their estimation again.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

All authors designed and conceived the survey. Adrienne Steffen, Sandra Rebholz, Claudia Hess and Sibylle Kunz evaluated the critical incidents concerning lesson design. Claudia Hess and Sibylle Kunz wrote the paper. All authors reviewed and approved the final manuscript.

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