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Language Support in a Student Laboratory for Chemistry in Secondary School

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Throughout the world, schools are visited by students with different native languages. Therefore, the linguistic competencies of the students are diverse. Dealing with this diversity is a great challenge for teachers in general, including in science subjects. To face this challenge, all institutions involved in education should adapt their teaching and learning to linguistic diversity to foster student's language competencies. Non-formal education, such as student laboratories, could enhance formal chemistry education and support students in learning the subject's contents and acquiring language competencies. To this purpose, language-sensitive and language-supportive learning settings for different chemical topics and contexts are developed to enable all students to participate actively and foster language competencies. The learning settings are implemented and evaluated at the Ludwigsburg University of Education (Germany) using a cyclical approach based on Participatory Action Research. Data from 147 students from seven learning groups of various grade levels and school types were collected before and after they experienced the work in student laboratories. The focus was on students' situational interests and their views on offered language-sensitive and language-supportive methods, tools, and activities. The data shows that the approach has a positive effect on students' situational interest. Methods that were especially helpful for the students are filtered. On this basis, implications are drawn for the application to other non-formal education offers.

Keywords: chemistry education, language-sensitive, secondary education, student laboratory

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Jezikovna podpora v laboratoriju za učence za kemijo na predmetni stopnji osnovne šole ter v srednji šoli

Sarah Kieferle in Silvija Markic

Po vsem svetu šole obiskujejo učenci z različnimi maternimi jeziki. Jezikovne kompetence učencev so tako raznolike. Spoprijemanje s to raznolikostjo je velik izziv za učitelje na splošno, tudi pri naravoslovnih predmetih. Da bi se spoprijeli s tem izzivom, bi morale vse ustanove, vključene v izobraževanje, prilagoditi poučevanje in učenje jezikovni raznolikosti ter tako spodbujati jezikovne kompetence učencev. Neformalno izobraževanje, kot so laboratoriji za učence, bi lahko okrepilo formalno izobraževanje o kemiji ter pomagalo učencem pri učenju vsebin predmeta in pridobivanju jezikovnih kompetenc. V ta namen se za različne teme in kontekste s področja kemije razvijajo jezikovno občutljiva in jezikovno podporna učna okolja, ki vsem učencem omogočajo aktivno sodelovanje in spodbujajo jezikovne kompetence. Učne okoliščine se izvajajo in evalvirajo na Pedagoški univerzi v Ludwigsburgu (Nemčija) z uporabo cikličnega pristopa, ki temelji na sodelovalnem akcijskem raziskovanju. Podatki 147 učencev iz sedmih učnih skupin različnih razredov in vrst šol so bili zbrani, preden so izkusili delo v laboratorijih za učence, in po tem. Poudarek je bil na situacijskih interesih učencev in njihovih pogledih na ponujene jezikovno občutljive in jezikovno podporne metode, orodja in dejavnosti. Podatki kažejo, da pristop pozitivno vpliva na situacijski interes učencev. Metode, ki so bile za učence še posebej koristne, so odbrane in posebej izpostavljene. Na tej podlagi so podane implikacije za uporabo v drugih ponudbah neformalnega izobraževanja.

Ključne besede: pouk kemije, jezikovna občutljivost, izobraževanje na predmetni stopnji osnovne šole, srednješolsko izobraževanje, laboratorij za učence

Introduction

Throughout the world, schools are visited by students with different native languages and linguistic competencies. Those linguistically heterogeneous students are confronted with the monolingual habitus in school (Gogolin, 2013). Dealing with this linguistic diversity is a great challenge for learning and teaching in school. Especially in science, such as chemistry, because the language used for teaching and learning chemistry content is quite different from everyday language (Markic et al., 2013). This results in various challenges for learning and teaching chemistry that need to be overcome. One of the difficulties students have to deal with in learning and teaching chemistry is the multi-layered and complex language that uses many technical and multisyllabic terms. In addition, using symbolic and mathematical aspects, as well as using diagrams and structures, often leads to comprehension problems (Childs et al., 2015). Studies like PISA (OECD, 2019) emphasise the relevance of language in science education and the disadvantages for students with a migration background in the German education system, particularly affected by learning in a second language (Lynch, 2001). Suggestions for dealing with students with different language competencies are given. There are language-sensitive (methods, tools, and activities that support students to use the language of instruction because they are second language learners, for example) and language-supportive (methods, tools, and activities that support students to develop linguistic competencies like using technical terms or specific grammar) methods, tools and activities that are effective in science education, in general, and in chemistry education, in particular (e.g., Childs & Ryan, 2016; Lee, 2005; Leisen, 2010; Markic et al., 2013). Nevertheless, to face this challenge, teaching and learning in schools are often insufficient. Non-formal education, like student laboratories, can complement the teaching and learning of chemistry in schools and support students in developing linguistic competencies. As part of the ERASMUS Plus project 'Diversity in Science towards Social Inclusion – Non-formal Education in Science for Students' Diversity – DiSSI', Ludwigsburg University of Education (Germany) is developing, implementing, and evaluating language-sensitive and language-supportive learning settings for student laboratories in chemistry for secondary school students.

Theoretical framework

Non-formal learning takes place outside of school in an open and unrestricted setting. It is structured, organised, and oriented towards the educational curriculum (Coll et al., 2013). Non-formal learning has both characteristics of formal learning at school and informal learning in students' leisure time (OECD, 2012). In science lessons, non-formal learning opportunities are often used to increase students' interest and motivation for science (Röllke & Großmann, 2022). For example, studies show that science-related non-formal activities have been associated with better student performance, increased student belief in their ability to solve science problems, and greater enjoyment of science learning (e.g., OECD, 2012; Rennie, 2014). In non-formal education programmes, such as school laboratories, students have the opportunity to engage with scientific topics independently as part of active forms of learning (Euler et al., 2015). Non-formal education also offers many opportunities for research. The student laboratory can be used for the development, implementation, and evaluation of scientific-didactic concepts (Guderian & Priemer, 2008). This includes the development of innovative teaching and learning methods and materials with potential for adaptation to everyday science teaching in schools (Affeldt et al., 2017).

A study by Brandt (2005) shows that even a single visit to a student laboratory has a significant positive short-term effect on students' self-concept and students' intrinsic motivation for the subject of chemistry. However, these effects can only be recognised for a short time after visiting the student laboratory (Engeln,2004; Brandt, 2005). Student laboratories are generally very well suited to foster students' interest in science and technology (Brandt, 2005; Engeln, 2004). However, this effect depends on various factors, such as students' age or their general interest in the subject or the topic (Brandt, 2005; Engeln, 2004). Furthermore, Guderian (2007) and Engeln (2004) find that the current interest of students develops positively, especially if there was already a positive attitude before the visit.

Accordingly, several factors influence the effectiveness of student laboratories. It seems that if student laboratories have positive effects on students in terms of interest, motivation, or even their self-concept, it depends not least on the design of the learning setting and the learning situation that is provided. Röllke and Großmann (2022) show that variables such as the perception of autonomy and competence have a significant influence on the intrinsic motivation of students in an out-of-school laboratory. These variables can be influenced by the design of the non-formal education offered. In addition, they were able to show that the students' pre-visit preparation for the student laboratory has an impact on their intrinsic motivation. Thus, there is a need for student laboratories that are structured in such a way that all students can benefit from them as much as possible. In this context, learning settings should be designed to allow as many students as possible to work independently and successfully on scientific topics. Suggestions for the design of student laboratories that have proven successful in heterogeneous learning groups exist. Affeldt et al. (2015) suggest multi-differentiated learning settings for student laboratories to enable all students to access and learn scientific content. The development of contextualised learning settings is based on a didactic model that takes into account the different personal interests of students, their different cognitive abilities, and their heterogeneous linguistic competencies (Affeldt et al., 2015).

Putting the focus on diversity and inclusion in school, various projects and studies in Germany (e.g., Affeldt et al., 2015; Groß & Reiners, 2012; Raguse et al., 2013; Scholz et al., 2016; Stäudel et al., 2007) have shown positive effects for student laboratories. Groß and Reiner (2012) investigate alternative forms of documentation for experimentation in heterogeneous groups in their study. The implemented forms of documentation are mainly not based on reading and writing texts but focus on pictures, video, and audio notes. This study shows that video documentation is particularly suitable for documenting experimentation in heterogeneous groups. Scholz et al. (2016) show in their study that pictures and pictograms are particularly suitable as supporting tools and differentiation for inclusive student laboratories when there is the highest possible correspondence between the picture and the real object. Graded tip cards have a great potential for differentiation during experimentation in student laboratories (Affeldt et al., 2019). These cards foster communication between students when doing experiments in small groups. By using them, students more frequently discuss and exchange their ideas on how to experiment. This exchange particularly supports students in doing experiments independently (Affeldt et al., 2019).

Two aspects that were shown to be particularly successful for teaching and learning chemistry in linguistic heterogeneous groups are the design of language-sensitive and language-supportive learning material (Affeldt et al., 2017) and the presentation of chemical content by contexts related to everyday life (Mamlok-Naaman & Mandler, 2020). Thus, for student laboratories that are focused on language-sensitive materials, a range of language-sensitive methods, tools, and activities need to be identified and evaluated as effective. Studies have shown that single methods, tools, and activities are applicable for language support during experimentation in student laboratories. Kieferle and Markic (2023) unite these positive findings and develop an effective connection between the evaluated methods to support students in dealing with language and to foster the development of language competencies to enable the active participation of all students during experimentation. A pedagogical approach for language-sensitive and language-supportive learning settings for student laboratories that enables all students' active participation during experimentation is developed in the present study from the perspective of the developers and tutors.

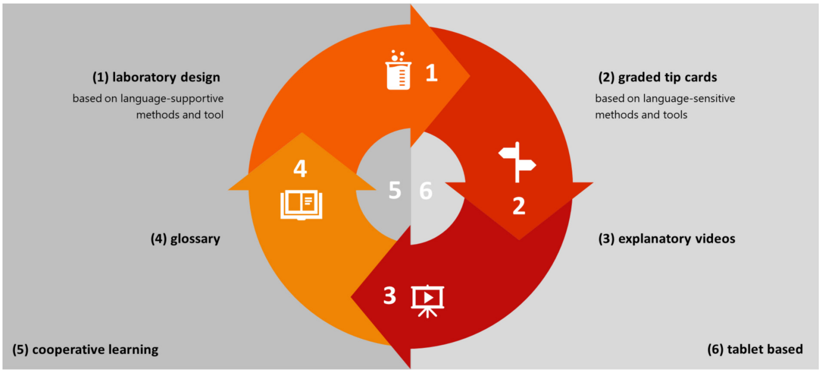
Learning Settings for a Student Laboratory Addressing Linguistical Difficulties

The present study was conducted in the context of the student laboratory at Ludwigsburg University of Education (Germany), which focuses on diversity in students' linguistic competencies. In this context, three learning settings (a mystery on substances and separation processes, a learning company on acidic and alkaline solutions, and planning a school trip on alkanols) are developed, implemented, and evaluated with two aims: 1) the development and implementation of a student laboratory that enables active participation of all students and 2) the generation of motivating learning settings for student laboratories that support secondary school students in conducting experimentation and developing language competencies. The development of the language-sensitive learning settings for the student laboratory is based on a cyclical process of development, implementation, evaluation, and adaptation oriented on Participatory Action Research, according to Eilks and Ralle (2002). More information on this can be found in the work of Kieferle and Markic (2023). The present paper focuses on the second aim. To achieve this, learning settings and language-sensitive learning materials were evaluated, focusing on the individual language-sensitive methods, tools, and activities and students' situational interests.

Students in a learning group differ not only in their language competencies; some students have mixed abilities, while others have special needs (Gardenswartz et al., 2010). Therefore, chemistry education has to deal with different language competencies and great heterogeneity (Childs et al., 2015). Thus, the development of language-supporting learning settings is based on methods, tools, and activities of language-sensitive teaching and includes opportunities to differentiate the chemical content and experimentation. Figure 1 shows the combination of approaches used for the learning settings for the student laboratory.

Figure 1

The approach of linguistic support in the student laboratory



The methods, tools and activities shown in Figure 1 enable differentiation in the demand of the content and language support of the students during experimentation using:

1. <u>A laboratory design based on language-supportive methods and tools:</u> We follow the idea 'content first, language second', which means that, first, students learn the fundamental concept in everyday language, then the scientific terms for the phenomenon are added (Childs & Ryan, 2016). In concrete terms, this means that the laboratory equipment is labelled and illustrated, and the learning material and support offers are marked with symbols. Students receive introductions to the context and information about the task via short videos. Longer text sequences are generally avoided.
2. <u>Graded tip cards based on language-sensitive methods and tools:</u> Each experiment is provided with graded tip cards that can be used individually by the students. Differentiation within a learning group (Markic et al., 2013) in the demand of their work and learning tempos is thus enabled (Städel et al., 2007). The graded tip cards are structured in steps that range from small hints to fully structured instructions. Thereby, implementations, observations, and findings could be supported individually. The graded structure of the tip cards allows the answering of complex scientific issues step by step without lowering the requirements in general (Affeldt et al., 2019). All graded tip cards are designed with language-sensitive methods and tools, according to Markic et al. (2013) and Leisen (2015). Specifically, visual aids, picture sequences, sentence starters, block diagrams, and sentence patterns are used to support

students in carrying out the experiment or formulating their observations and findings. In concrete terms, visual tools, sequences of pictures, beginning of sentences, block diagrams and sentence patterns are used to support students in performing the experiment or to formulate their observations and findings.

3. Explanatory videos: The short videos give information about important chemical content. Students can use explanatory videos individually so that differentiation within the learning group is possible. Explanatory videos are suitable for getting information to a similar extent as text sequences (Reinke et al., 2021). The advantage of explanatory videos is that they trigger positive emotional reactions in students, which increases motivation and interest in learning (Findeisen et al., 2019; Morris & Chikwa, 2014).
4. A glossary: The glossary contains short descriptions of technical terms (e.g., hypothesis) or short explanations of scientific methods (e.g., filtration). Since there are often concepts behind the technical terms used in chemistry, the use of a dictionary is usually not sufficient to support students, especially those who speak German as a foreign language. A glossary with well-chosen key terms, which also includes pictures, for example, and links the term to the concrete concept, has proved helpful (Miller, 2009).

In addition, the learning settings are developed using a tablet-based and cooperative approach.

5. Tablet-based: All work tasks, experimental instructions, and the contextualisation and organisation of the learning settings are designed digitally. Students use tablets to write their lab reports. The tablet is used as a synchronous, easy-to-use, and multifunctional experimental tool. It allows several sensory channels to be operated simultaneously and as needed (Huwer et al., 2018). The use of tablets in chemistry education has a positive effect on students' motivation (Rikala et al., 2013) and is also a differentiation possibility that is seen as very attractive by all students in an inclusive learning group (Greitemann & Melle, 2020).
6. Cooperative learning: The learning settings were developed with a special focus on communication and interdependent support between students. As part of the learning settings, the students are confronted with different problems and thinking tasks, which they have to solve together using the cooperative method of 'think/pair/share'.

Research Question

Students' opinions are critical for the effectiveness of forms of non-formal education like a student laboratory. In the sense of triangulation, the present study evaluates the learning settings and a pedagogical approach developed and presented by Kieferle and Markic (2023) from the student's perspective.

Therefore, this study is guided by the following research questions:

1. Which methods, tools, and activities are suitable for language-supportive learning settings for a student chemistry laboratory?
2. What influence do the language-supportive learning settings have on student's situational interest?

Methods

For the purpose of the present study, data from students who visited the student laboratory at the Ludwigsburg University of Education, Germany, over six months are collected. The study has a pre-post design.

Sample

The survey is carried out in seven learning groups from different comprehensive schools and secondary modern schools from different regions in southwestern Germany with a total of 147 students; 52.20% of the participating students are male, 44.90% are female, 1.40% are gender-diverse, and 1.40% are without indication. The schools were from urban (87.5%) and rural (12.5%) areas and were also attended by students with first or second-generation migration backgrounds. A total of 87.70% of the students were born in Germany, and 12.30% were born in another country. Regarding language, 33.30% of the students speak German as a native language, 10.10% speak German and one other language as a native language, and 56.50% speak German as a second or foreign language. 0.1% did not indicate their native language. Thus, more than half of the students speak the language of instruction (German) as a second or foreign language.

Before data collection, the approval of parents and students was requested. All students were informed of their right to withdraw from the study.

Instruments

For the purpose of generating quantitative data, a student questionnaire in pre-post design is used that contains items that are established in their respective field (situational interest and use of graded tip cards). The questionnaires consist closed-ended (Yes/No) and Likert-scaled questions. Additionally, an open-ended question is given.

a) The pre-test questionnaire consists of two parts:
   i) The first part collects general information on the participants. The students were asked for their age, gender, country of birth, and native language.
   ii) The second part consists of 5 closed-ended questions about students' experience of dealing with graded tip cards (Affeldt et al., 2019).

b) The post-test questionnaire consists of two further parts:
   iii) The third part is comprised of 10 Likert items (5-step). The items refer to students' situational interest and one open-ended question about the three things that were most interesting to students during the work at the student laboratory on that day (Chen et al., 2001).
   iv) The main part of the questionnaire consists of 30 Likert items (4-step). The students are asked about the use of the explanatory videos (4 Likert items), language support by using the glossary and the labelled workstations (4 Likert items), and the experience of working with graded tip cards (22 Likert items and 2 items based on closed-ended questions (Affeldt et al., 2019).

Research Design

The development of language-sensitive and language-supportive learning settings for the students' laboratory is based on Participatory Action Research (Eilks & Ralle, 2002). In a cyclical process consisting of development, implementation, evaluation, and adaptation, quantitative data is generated in each cycle.

Data Analysis

a) Pre-test questionnaire:
   ii) The Likert items are analysed with descriptive statistics based on relative frequency to make conclusions about the student's previous experiences on work with graded help cards.

b) Post-test questionnaire:
   iii) The 5-step Likert items referring to the situational interest items are analysed using descriptive statistics. A frequency statistic is carried out to make conclusions about the students' situational interests. The data of the open-ended question are categorised and sorted according to frequency of mention to show in more detail where the students' interests focus mainly.

iv) The 4-step Likert items and the closed-ended questions referring to the individual support offers are analysed using descriptive statistics. For the analysis, items were grouped into categories so that more specific conclusions could be made about the use and the impression of the students regarding the individual support offered. A frequency statistic was calculated for each item so that the trends are clearly shown.

Results

a) Pre-test:

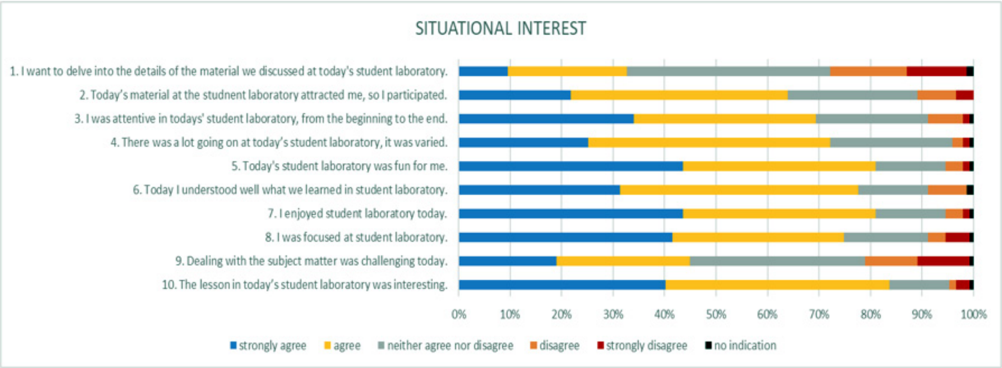
The data collected in the pre-test questionnaire show that more than half of the students in this group (69.6%) did not use graded tip cards in chemistry lessons prior to the visit to the student laboratory.

b) Post-test:

Figure 2 shows the evaluation of the items concerning students' situational interest in doing experiments in the student laboratory. The results show clearly (Figure 2; Items 5 and 7) that most of the participating students had fun during the work in the student laboratory. 80.2% stated that they can strongly agree or agree with the statement 'I enjoyed student laboratory today', and 80.9% stated that the visit to the student laboratory was fun for them. It should be highlighted here that not only 83.6% of the students stated in item 10 (Figure 2) that they found the student laboratory interesting, but 77.6% also stated in Item 6 that they understood what they were doing there.

Figure 2

Results concerning students' situational interest



The results of the open-ended question, in which the students had the opportunity to indicate three things they liked the most in the visit to the student laboratory (students N=123), the most frequently mentioned (100 mentions) were the chosen contexts and individual experiments, for example, 'the story' (S62) or 'the skin care products' (S106). Students often mentioned doing experiments (49 mentions) in general and the laboratory and laboratory clothing (40 mentions) in particular. Statements that can be categorised as inquiry-based learning (39 mentions) were also frequently mentioned. In particular, students mentioned 13 times that they most liked the results of the experiments, for example, 'the comparisons' (S125), 8 times working independently, and 7 times they mentioned inquiry, for example, 'find out what the problem is' (S101).

During the work in the student laboratory, graded tip cards were used by more than half of the students (62.2% said they had used them) in general. 45.5% of the students indicated that they used at least one card in each experiment. More than half of the students only decided to use a card when they were completely helpless in their work (63.4% strongly agreed or agreed to the statement 'I only decided to use a tip card when I was completely stuck'). If they used a tip card, they decided to do so with the team members (57.7% strongly agreed or agreed to the statement 'I decided to use the tip cards with my classmates').

The results show that 60.3% of students could not do the experiments without the help of graded tip cards. That is in line with the agreement of 55.8 % of students, which indicates that they were able to do the experiments better with the tip cards marked with test tubes (cards to support the performance) (Figure 3; Item 4). When students decided to use a tip card, 43.6% of them always took the first card first, worked with it and then took the second tip card (strongly agreed or agreed to the statement 'I always took the first tip card first, worked with it and then took the second tip card'); 46.1% of the students do not use the graded tip cards in this way. Here, the results showed that only 27.0% of the students read the first tip card and then immediately took the second one (strongly agreed or agreed to the statement 'We read the tip cards first and then immediately took the second one').

Figure 3

Results concerning students' opinion on the use of graded tip cards

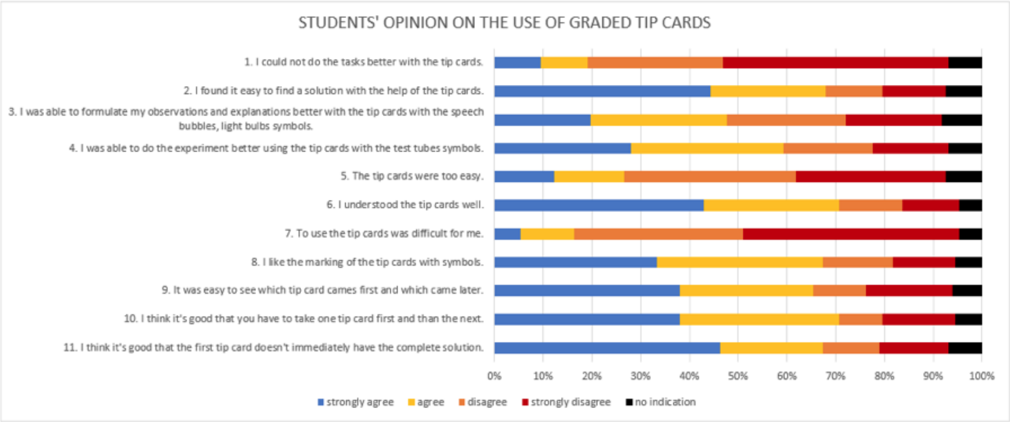
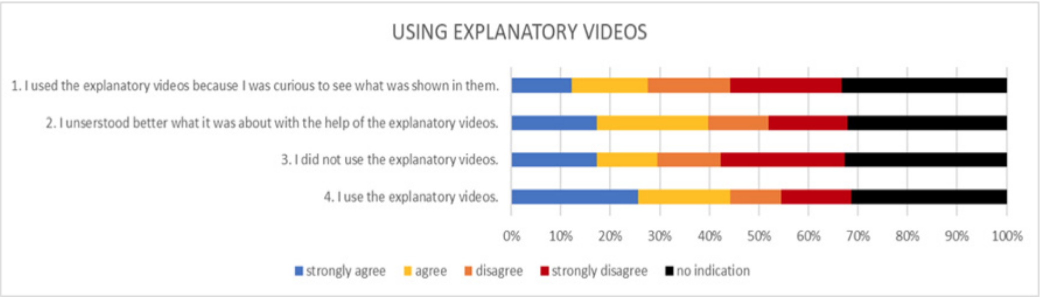


Figure 3 shows the results for students' opinions on the use of the graded tip cards. Just a few students mentioned difficulties with the use of differentiated and graded tip cards (Figure 3; Item 7). More than two-thirds of the students stated that they could do the task better with the tip cards (69.9% disagree or strongly disagree item 1). This is consistent with the 66.7% of students who understood the graded tip cards well (Figure 3; Item 6) and the 64.1% who easily found a solution using the cards (Figure 3; Item 2). Only a few students (22.4%) disagreed that it was beneficial to take the tip cards one after the other (Figure 3; Item 10) and that the first tip card did not immediately present the complete solution (24.4%) (Figure 3; Item 11). Furthermore, the results show that most students liked to have the chance to do the experiment without any help (79.5% strongly agreed or agreed to the statement 'I think it's good to have the chance to do the experiment without help').

Figure 4 shows the evaluation results referring to the explanatory videos. The high percentage of no indication is due to the fact that 32 students visited a learning setting which did not contain explanatory videos. The sample of students who had the opportunity to use explanatory videos includes 106 students; 44.2% of those students stated that they used offered explanatory videos during their work (Figure 4; Item 4). For 39.7% of students, watching the video resulted in a better understanding of the topic (Figure 4; Item 2).

Figure 4

Results concerning the use of explanatory videos



Further results referring to the labelled workstations and the glossary show that they supported students in dealing with technical terms; 66.0% of students strongly agreed or agreed to the statement, 'The labelling of the workstations with the equipment made it easier for me to use the lab equipment'. In addition, almost half of them (46.8%) found that the glossary was helpful in understanding difficult terms (strongly agreed or agreed to the statement 'I found the glossary helpful to understand difficult terms').

Discussion

Non-formal forms of education, like student laboratories, are often used, especially in science education, to help students become more interested and motivated in science. Therefore, the perception of autonomy and competence has a significant influence on students' intrinsic motivation in an out-of-school laboratory (Röllke & Großmann, 2022). The results of the study presented in this paper support the assumptions of Röllke and Großmann. The high amount of students' feedback relating to the context of the learning settings, the laboratory itself, and the laboratory clothing suggests the potential of student laboratories. The positive feedback regarding the inquiry-based learning approach shows that perceived autonomy is important for students' situational interests.

In this study, we focussed on students' linguistic diversity and wanted to determine which methods, tools, and activities of language-sensitive and language-supportive teaching are appropriate for student laboratories to enable all students to experiment autonomously and what influence language-sensitive learning settings have on students' situational interest.

In the context of this study, different types of language-sensitive and language-supportive support (graded tip cards, labelled workstations, glossary, and explanatory videos) are implemented and evaluated from the side of the users. With regard to the effectiveness of the support offers it can be said that many of the learners assessed graded tip cards as motivating them for independent experimental work and as supporting them in dealing with the experiments without any help from a supervisor in the laboratory. This is in line with the findings of Stäudel et al. (2007) and Affeldt et al. (2019), who suggested that graded tip cards can have a positive influence on students' autonomy during experimental work. However, it should be noted that approximately three quarters of the students used the graded tip cards for the first time. On the one hand, the discussion can be about whether this is the effect of working with something new; on the other hand, the usefulness of the graded tip cards is more than obvious in the results. Thus, we can, in particular, agree with Affeldt et al. (2019) that the graded tip cards have the potential to challenge and support communication among the students in small group work and promote discussion about ideas, for example, to conduct experiments. In particular, performing the experiments is supported by graded tip cards, which are evaluated as helpful and positive by students. A majority of students stated that they prefer doing experiments without any support. This point is supported by other studies, which also show that students particularly appreciate independent and cooperative learning settings (Juntunen & Aksela, 2013). However, participants still used the graded tip cards offered. This shows that students' autonomy in decision-making if and when using the offered support for their learning process is evaluated as extremely positive. This is especially true considering the fact that the students were not experienced in this kind of work, and there was less time to explain the methods compared to a classroom situation.

The results show that language-sensitive and language-supportive methods, tools, and activities such as explanatory videos can foster a better understanding of the chemical content behind the experiments and that glossaries help students deal with technical terms.

Illustrated and labelled workplaces were seen as particularly helpful in dealing with laboratory equipment students. This is in line with the finding of Scholz et al. (2016), who showed that pictures and pictograms are particularly appropriate as supporting tools and differentiation for an inclusive student laboratory when there is the highest possible correspondence between the figure and the real object.

In conclusion, the opportunity to decide individually if and in which amount of support is used is especially well accepted by students. At this point, we can assume that the combination of different support opportunities, in particular, has a positive influence on situational interest and finally results in a positive experience in the student laboratory and for students learning chemistry. The range of graded tip cards, explanatory videos, illustrated workplaces, and the glossary make it possible to support the students individually in terms of both the type and the intensity of support. A particular advantage here is that there is no need to use any support offered. The results also show that 79.5% of students liked autonomy when choosing whether they wanted to use one of the support offers. Most important, however, is that this study supports the results of Kieferle and Markic (2023) that the offered methods and tools in combination do support students' active participation in work in the student laboratories. Thus, in terms of triangulation, the combination of different methods and tools can be seen as secure. The student's view of the different support offers confirms our conclusion that direct, simple, and individual support is particularly beneficial and motivating during experimentation. The freedom of choice and autonomy also have a positive effect on students' situational interest in student laboratories. Doing experiments in small groups can be supported in a non-formal setting with the help of the above-mentioned support opportunities and enables all students to deal with the learning material actively.

Conclusions

The methods and tools used in student laboratories for language support and promotion of the development of language competencies of students can be adapted to different learning contexts and used in different learning situations based on their flexible structure. For example, the language-sensitive and language-promoting approach is not dependent on the context and content. Therefore, the context can be adapted to students' age levels, and the content can be adapted to students' learning levels or school type. The explanatory videos and the graduated tip cards make it possible to use the learning settings with or without students' previous experience with chemical content or inquiry-based learning. The DiSSI approach for language-sensitive and language-supportive work presented here grounds on a combination of different methods, tools, and activities and can be used in other non-formal education offers with various learning settings. Thus, many different learning settings in non-formal education offers, such as museums, laboratories, or science centres, can be designed in such a way that they are language-promoting and language-supporting.

The language-sensitive and language-supportive approach can also be used in formal teaching in schools. The student laboratory can act as a link in this process. On the one side, teachers can use a visit to the student laboratory as a kind of 'in-service teacher training' while learning more about new tools and methods, which she/he can adapt to their teaching. On the other side, teachers can also learn more about the usage of language and the meaning of diagnostics to better understand their students.

The presented study only encompasses a small sample, which means it cannot be considered representative. Nevertheless, it is an example of the practical implementation of language-sensitive and language-promoting approaches that need to be enhanced.

Based on the results presented here and also in Kieferle and Markic (2023), we suggest the involvement of pre-service chemistry teachers in the work of student laboratories that implement the DiSSI approach. Thus, pre-service chemistry teachers will not only theoretically learn about language-sensitive and language-supportive teaching and learning but experience them in practice. Additionally, tutoring in a student laboratory offers a chance to observe the work of students more in detail compared to the classroom situation in schools. Here, the work of smaller but also different groups is in focus.

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