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Why Austrian students are (not) interested in chemistry education - An interest study concerning chemical content and experimental activities

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Structured Abstract

Background: Over the last decades, several international studies have addressed the issue of student interest in science and chemistry education. The findings of these studies describe the phenomenon of declining interest over the school career. However, older as well as more recent studies show that everyday references and independent experimentation can promote interest in chemistry education. Students themselves stress the importance of everyday references in chemistry education.
Purpose: Currently, there is no actual interest study that deals with the interest of Austrian students in relation to everyday references and experimental activities in chemistry education. This study aimed to contribute to the research field of interest studies in chemistry education by analyzing the interest of Austrian students in chemical content with relation to everyday references and experimental activities.
Sample/setting: A total of 621 lower (67.1 %) and upper (32.9 %) secondary school students from Austria participated in this study. The students were informed on the use of their data for this study; ethical guidelines were followed. An online questionnaire was used and sent to the schools. The questionnaire was then forwarded by the schools to the students.
Design and Methods: The questionnaire consists of two parts: (1) personal data, such as gender, school level and whether the school has its own laboratory lessons for chemistry education and (2) a total of 47 items on interest in chemistry content with and without everyday references as well as interest in experimental activities and frequency of experimental activities in chemistry education and 4 items on chemistry-related self-concept. The interest in chemical content with or without everyday references was analysed descriptively and an analysis of variance was calculated. The impact of chemistry-related self-concept, gender, school grade and lesson type on the interest in chemical content with and without everyday references was analyzed using a path model and the interest in experimental activities was analyzed descriptively.
Results: The findings show that learners are significantly more interested in content with everyday references (strong effect) than in content without everyday references. Furthermore, this study showed that independent experimentation is of greatest interest for students, but at the same time occurs relatively rare in chemistry lessons. Less popular, on the other hand, are abstract activities such as formulating reaction equations in the context of experiments. Results also reveal that chemistry-related self-concept is a moderate/strong predictor for the interest in chemical content for both with and without everyday references. The other predictors (gender, school grade, lesson type) each only have a weak influence on interest in this content. However, results reveal that interest in chemistry content declines over the school career, just as other studies have previously found a declining interest in chemistry/science education.
Conclusions: The study provides new and current insights into the interest of Austrian students in chemical content with and without everyday references in chemistry education. Furthermore, the study shows which experimental activities students are most interested in and how often experimental activities occur in chemistry lessons. One way of counteracting the loss of interest could be to teach with as much of the focus on everyday life as possible, considering the interests of female and male students when choosing the everyday reference and enabling the students to experiment independently, preferably with reference to everyday life, as often as possible. After all, this is what summarizes the greatest interests of students in chemistry education in this study. However, further research will be required on how to counteract this loss of interest over the school career.
Keywords: *interest in chemistry education, interest study, everyday references, experimental activities*

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1 Introduction

In recent decades, students have been offered a wide range of learning opportunities, including science education. Whether and which of these learning opportunities are taken up depends to a large extent on the structure and dynamics of the individual's existing interests (Dierks et al., 2016; Krapp, 2000). In principle, students often have a positive attitude towards science. However, this attitude decreases significantly during their time at school. In terms of interest, a decline in interest has been observed in the past, especially in science education (Hoffmann et al., 1998; Köller et al., 2020; Sjøberg & Schreiner, 2019). In addition, those who are interested often cite secondary reasons for their greater interest in science, such as professional reasons or passing examinations and with regard to science lessons in school, students often criticize the lack of relevance to everyday life, with pure factual learning often being described as boring (Cerini et al., 2003). In chemistry education, the importance and significance of everyday references have been highlighted in several studies (Apotheker, 2019; Childs, Hayes, & O'Dwyer, 2015; Ulusoy & Onen, 2014). Students themselves stress the importance of everyday relevance, saying that they can improve their chemistry experience by making teaching more practical and student-centered. Chemistry education will then appear to the students to be less abstract and meaningless, as the content they learn can be applied in their everyday lives. In particular, students with no career aspirations in chemistry-related professions are aware of chemistry's importance through everyday references (Barke et al., 2012; Broman & Simon, 2015).

So far, it does not seem to have been optimally successful in arousing learners' interest in science education. However, previous research results show that interest is a central influencing factor for successful learning (Elster, 2010; Hidi & Renninger, 2006), and that an intrinsic motivation to learn based on interest is very likely to promote learning (Deci & Ryan, 1993; Krapp, 1998, 2000). For this reason, the topic of interest in relation to everyday references should be investigated further, especially in the area of chemistry education, since, as explained above, the interest of students in chemistry decreases during their school career and everyday references have been identified by research, but also by the students, as an important element of chemistry teaching. Currently, there is no actual interest study that deals with the interest of Austrian students in relation to everyday references in chemistry education. Therefore, this paper attempts to fill this research gap by presenting an interest study on this topic. An online questionnaire was used to investigate the interest in chemistry education with relation to everyday references. A total of 621 students from lower and upper secondary school participated in this study focusing on the interest in chemical content with relation to everyday references and without everyday references and the interest in experimental activities. The results may provide current insights about students' interest in chemistry education in Austria.

2 Research Background

2.1 The concept of interest

Interest is undoubtedly a positive factor for learning and is generally considered to be a multi-dimensional motivational variable that includes both cognitive and affective facets (Hidi & Renninger, 2006; Krapp, 1998; Singh et al., 2002). It is always content-specific as a result of interaction with the environment or an object (Schiefele, 2009; Valisner, 1992). A distinction is usually made between two forms of interest. On the one hand, this is the individual interest in a subject which develops gradually. It includes subject knowledge and values and is seen as an enduring preference for a particular activity or thing. Situational interest, in contrast, is a specific state that is triggered by a specific stimulus, e.g., through an interesting lesson design. It is of short duration and occurs spontaneously in different situations. It depends on several factors to achieve a situation where both are present including the learner's personality, the learning context, and the learner's opportunities for self-directed activity (Deci & Ryan, 1993; Krapp, 1992).

2.2 Students' interest in science and everyday references

The interest in science is divided into two categories by Krapp and Prenzel (2011): general interest in science and interest in specific topics, contexts, or activities within a subject. For both aspects, studies report contradictory findings, e.g., some studies show relatively low interest in science among 15-year-old students and others report quite high interest in this area among 15–17-year-olds (Holstermann & Bögeholz, 2007; Prenzel et al., 2007; Vedder-Weiss & Fortus, 2012), especially for applications in everyday life (Häussler et al., 1998; Hoffmann et al., 1998). Unfortunately, however, several studies show that interest in science seems to decline during the school career (Gräber, 1992a; Hoffmann et al., 1998; Köller et al., 2020; Sjøberg & Schreiner, 2019). Gebhard et al. (2017) pose the question of whether, in view of the dwindling interest in the natural sciences, a youth is growing up who, on the one hand, are turning away from the natural sciences but, on the other hand, are taking unreflective advantage of technical and scientific developments. They note, however, that valuing science education and valuing science are two different things. The importance of the natural sciences is rated very highly by students, but at the same time the interest in science education is quite low. Hoffmann et al. (1998) found in their IPN-interest study on physics that a lesson which is linked to the experiences and everyday life of the students is more interesting than the purely technical study of general laws of nature, physical laws, or the explanation of experiments. The ROSE study (Relevance of Science Education), in which lower secondary school students from about 40 countries took part, also identified the low relevance of the subjects taught to the lives of young people as being responsible for the lack of interest in science education (Schreiner & Sjøberg, 2004; Sjøberg & Schreiner, 2019). According to Elster (2007a, 2010), students' acceptance of science education is higher when they experience it as personally or socially meaningful. In her findings for German and Austrian students based on ROSE, Elster (2007a, 2010) states that science lessons arouse interest when they relate to everyday situations, when the learning content relates to the human body, when astounding phenomena are dealt with or when the social significance is addressed. For chemistry education, according to Gräber (1992a), a poor image of chemistry and technology is often given as a reason for the lack of interest. Chemistry is not only associated with benefits, but above all with dangers for people and the environment. The difficulty of the subject, since some of the content in chemistry lessons is abstract and thus requires thinking on a formal-operational level, is also seen as a cause for the declining interest. In addition, students criticise the lack of relevance of chemistry lessons to their everyday lives (Gräber, 1992a). According to Broman & Simon (2015), students have an interest in chemistry per se, but the chemistry lessons are seen as less interesting. The authors identified the lack of relevance to everyday life as a major reason for the lack of interest in chemistry education. Similar to the findings of Gräber (1992a), the majority of the students in this study expressed the wish for more relevance to everyday life as a suggestion for improving chemistry education (Broman & Simon, 2015).

2.3 Students' interest in experimentation and everyday references

The PISA study (2006) showed that in Austria, 15–16-year-old students experiment significantly less independently than the OECD average, as only one in six learners reported having conducted their own practical experiments in school. Similarly, students were less able to apply concepts to everyday references (Schreiner, 2007). Current data in this respect, for chemistry education, are not known to the authors for Austrian students and will therefore be presented descriptively in this paper. However, older as well as more recent studies show that practical experimentation, often also called hands-on experimentation, can promote interest in chemistry education (Gräber, 1992b; Ochsen et al., 2022; Shirazi, 2017). Gräber (1992b) found a high interest in conducting experiments for both girls and boys (8th-10th grade). 71.0% of the girls and 78.6% of the boys indicated a great or very great interest in conducting experiments. Similar results were obtained by Schminke et al. (2007) for upper secondary school students, who found practical constructive work the most interesting, while theoretical work or teacher-centered receptive work was perceived as the least interesting. Positive effects for hands-on activities have also been found in biology lessons. Here, these activities were differentiated according to dissection, working with microscopes, experimentation, and classification. In addition to positive effects, however, negative effects on interest were also found in one case, whereby most hands-on activities showed no influence on the students' interest (Holstermann et al., 2010). It has also already been shown for chemistry education that not every experiment always has to promote interest. In their study, Walpuski & Hauk (2017) first identified potential improvements for the use of experiments in chemistry lessons, such as a stronger emphasis on a question or a more intensive discussion of the results. They then implemented these improvements in experiments in a control group design and found that the students in the intervention group were more interested than the students in the control group and thus the subject-didactic design of experiments is of important relevance. An important part of this subject didactic design is also the combination of everyday references and experimentation. In this context, Schminke et al. (2007) have determined for upper secondary school students that chemistry lessons with experiments that contain everyday references have a positive effect on interest. The authors found that the students had significantly higher interest than the control group without everyday references. The decrease in interest was also significantly lower when experiments with everyday references were used. Wanjek (2000) also found a positive influence on the interest of lower and upper secondary school students through everyday experimentation in the classroom. In this study, the topic of acids and bases was addressed using products (household chemicals) from the student's everyday lives. Based on the results of the study, the author concludes that experimental, everyday referenced chemistry teaching promotes interest and is of equal interest to female and male students.

2.4 Interest and self-concept

Research has already found that interest is also influenced by other variables, such as self-concept (Denissen et al., 2007). It is understood as part of declarative memory, which consists of self-referral cognitive information, such as knowledge of weakness and strengths and preferences (Shavelson et al., 1976). In other words, the self-concept refers to a mental model that contains ideas, abilities, estimations and evaluations of oneself and includes all cognitive representations of one's abilities (Schöne et al., 2002). It is assumed that different self-concepts exist for different domains, for example for different school subjects (Köller, 2004). Its strong relationship with outcome variables such as achievement is a main reason for the interest in academic self-concept (Jansen et al., 2014). For example, Rüschenpöhler & Markic (2020) found a strong association between chemistry self-concept and learning goals. It seems that students with a positive self-concept in chemistry tend to be more persistent in their learning of chemistry and have more enjoyment in thinking about chemistry. Through a shared relationship with achievement, self-concept and interest appear to develop and evolve. This tends to happen generally in three steps. First, students' achievement in one area clearly influences their growing self-concept in a subject (e.g. I did well in chemistry education, so I'm good at chemistry). Then, of course, their self-concept will have an effect on their interest in that area (e.g. I'm good at chemistry, so I want to enroll in more chemistry courses). The increased interest of the students will contribute to their desire to

take part in additional activities related to this area in the hope of gaining further successful experiences, and the sequence will be repeated (Marsh et al., 2005; Nagy et al., 2006).
As just described, studies show a predominantly positive influence of everyday references on students' interest in science and chemistry education. The same applies to student-oriented experimentation, especially in combination with everyday references. However, there is no actual interest study that deals with the interest of Austrian students in relation to everyday references in chemistry education. Therefore, further research is needed, especially for chemistry education. Thus, this study aims to contribute to the research field of interest studies in science and especially chemistry education by analyzing the interest of lower and upper secondary school students in chemistry education with relation to everyday references. In this context, we will present what students are particularly interested in and what they are less interested in. Furthermore, we present descriptively how interested students are in experimental activities (e.g., conducting their own experiments) and how often experimental activities occur in chemistry lessons.
As a consequence, we have chosen to investigate the following research questions:

RQ1: What chemical content (with or without everyday references) are students most interested in?

RQ2: What impact do chemistry-related self-concept, gender, school grade and lesson type (laboratory lessons/normal chemistry lessons) have on the interest in chemical content with and without everyday references?

RQ3: Which experimental activities are students most interested in and how often do experimental activities occur in chemistry education?

3 Methods

For this study, an online questionnaire was used (to be completed once), which was created using the software Limesurvey and sent to the schools. The questionnaire was then forwarded by the schools to the students. The questionnaire consists of two parts: (1) personal data, such as gender, school level and whether the school has its own laboratory lessons for chemistry education and (2) a total of 47 items on interest in chemistry content with and without everyday references as well as interest in experimental activities and frequency of experimental activities in chemistry education and 4 items on chemistry-related self-concept (all closed items). The scales (items) used are described in detail in section 3.2 (Measures).

3.1 Sample

A total of 621 lower (67.1 %) and upper (32.9 %) secondary school students from Austria participated in this study. As not all students attend an upper secondary school after lower secondary school, the number of participating upper secondary school students is expectedly lower. The data collection was realized by means of an online questionnaire in spring 2022. The time required to finish the questionnaire was about 25 minutes. Participation was voluntary and anonymous, i.e., all data were collected and analyzed anonymously. Students could withdraw from the study at any time without negative consequences. All study participants were informed about the scientific purpose of the study. Of all participants, 317 were female, 288 were male, and 16 were non-binary persons. Participants had a mean age of M = 14.69 years (SD = 1.71). A special feature in Austria are laboratory lessons, which are part of chemistry lessons. If the school offers laboratory lessons, experimentation usually takes place in these lessons and the theory usually in corresponding theoretical chemistry lessons. If the school does not have its own laboratory lessons, experimentation takes place in normal chemistry lessons. The majority of the participating students' schools (66.3 %) have their own laboratory lessons. 33.7 % of the students stated that the school does not have its own laboratory lessons.

3.2 Measures

Interest in content of chemistry education with and without everyday references: We measured learners' interest in the content of chemistry education with 12 items each, without relevance to everyday life (e.g., "How interested are you in learning about… How a rechargeable galvanic element works") and corresponding items with relevance to everyday life (e.g., "How interested are you in learning about… How the battery works in a cell phone"). Each item could be answered on a four-point Likert-scale ("1 = not interested" to "4 = very interested"). The likert scale was chosen identically to the ROSE study (Sjøberg & Schreiner, 2019). Two Items were adapted, one from Holstermann & Bögeholz (2007) and one from Fürtbauer (2015). All other items were developed independently. Both scales (without everyday relevance; a = 0.90) and with everyday relevance (a = 0.83) show good reliabilities.
Chemistry-related self-concept: In general, the self-concept refers to a mental model that contains ideas, abilities, estimations, and evaluations of oneself and includes all cognitive representations of one's abilities (Schöne et al., 2002). Students' subject-specific ability self-concept regarding academic performance in the field of chemistry was assessed using the scales for measuring the school self-concept from Schöne et al. (2002) (4 items; a = 0.94; e.g., "I am talented in chemistry"; "Learning new things in chemistry is easy for me"). A five-point Likert scale was used from "1 = strongly disagree" to "5 = strongly agree".

Interest in experimental activities in chemistry education: We measured learners' interest in experimental activities in chemistry education with 9 Items. Each item could be answered on a four-point Likert-scale ("1 = not interested" to "4 = very interested", e.g., "How interested are you in…Conducting an experiment by yourself" or …"Observe how the teacher conducts an experiment"). Again, the Likert-scale was chosen identically to the ROSE study (Sjøberg & Schreiner, 2019). Items were adapted from Hoffmann et al. (1998), Hochwarter (2016) or developed independently. This scale has a good reliability of $a = 0.83$.
Frequency of experimental activities in chemistry education: We measured the frequency of experimental activities in chemistry education with 10 Items. Each item could be answered on a four-point Likert-scale ("1 = never" to "4 = often", e.g., "The teacher demonstrates experiments using special chemical equipment" or "In class we conduct experiments ourselves with everyday objects"). This Likert-scale was chosen in accordance with the ROSE study (Sjøberg & Schreiner, 2019). All items were adapted from Hochwarter (2016). This scale has a good reliability of $a = 0.81$.

4 Results

The results are presented in the order of the research questions.

4.1 Interest in content of chemistry education with and without everyday references (RQ1 & RQ2)

We measured learners' interest in the content of chemistry education with 12 items each, with and without everyday references. The scale with everyday references has a mean value of $M = 2.57$ ($SD = 0.58$), the scale without everyday references has a mean value of $M = 2.25$ ($SD = 0.65$). Table 1 shows the descriptive analysis of the top three most interesting and least interesting contents (of all 24 items). The items are ordered by descending mean values. Mean values (M) and standard deviations (SD) of the items are shown (Table 1). The results show that the top three most interesting items are all related to everyday life. The students are most interested in "why fireworks glow in color" ($M = 3.20$; 81.5 % more interested/very interested, 18.5 % rather not/not interested), followed by "how the battery works in a cell phone" ($M = 3.01$; 75.5 % more interested/very interested, 24.5 % rather not/not interested) and "how alcohol can be separated from wine" ($M = 2.84$; 65.1 % more interested/very interested, 34.9 % rather not/not interested). The opposite is found for the items that are not related to everyday life. Here, the students seem to be least interested, as "the polarity of substances" ($M = 2.05$; 28.2 % more interested/very interested, 71.8 % rather not/not interested), "the calculation of simple chemical processes" ($M = 2.04$; 30.6 % more interested/very interested, 69.4 % rather not/not interested) and "the function of a rechargeable galvanic element" ($M = 2.03$; 29.9 % more interested/very interested, 70.1 % rather not/not interested) show the lowest mean values of all items (Table 1).

Tab. 1. Descriptive analysis of the top three most interesting and least interesting contents.

Item	*M*	*SD*
All 12 Items with everyday references	2.57	0.58
All 12 Items without everyday references	2.25	0.65
(1) Why fireworks glow in color.	3.20	0.90
(2) How the battery works in a cell phone.	3.01	0.92
(3) How to separate the alcohol from a wine.	2.84	1.05
(4) What polar and non-polar substances are.	2.05	0.87
(5) How to perform calculations on simple chemical processes.	2.04	0.94
(6) How a rechargeable galvanic element works.	2.03	0.93

Note. Sorted by descending mean values. (Four-point Likert-scale "1 = not interested" to "4 = very interested"), $n = 621$.

The item of "the rechargeable galvanic element" ($M = 2.03$) also shows that its similarly formulated item with everyday reference, "how a rechargeable battery in a cell phone works" ($M = 3.20$), is more interesting for the students. This tendency can be seen for the other items shown in Table 1 and is shown again descriptively for this sample items in Table 2. The results show that for all sample items (see Table 2) the variant formulated with everyday references is more interesting for the students than the variant without reference to everyday life. A repeated-measures analysis of variance confirms this trend (scale with everyday references, $M = 2.57$ ($SD = 0.58$); scale without everyday references $M = 2.25$ ($SD = 0.65$)) and shows that interest in chemical content with reference to everyday life is significantly greater than the interest in content without reference to everyday life ($F(1,620) = 354.72$, $p < .001$, $\eta_p^2 = .36$, $n = 621$). The effect size f according to Cohen (1988) is 0.76 and corresponds to a strong effect.

Tab. 2. Descriptive analysis of the top three most interesting and least interesting contents with/without everyday references.

Item with everyday reference	*M (SD)*	Item without everyday reference	*M (SD)*
All 12 Items	2.57 (0.58)	All 12 Items	2.25 (0.65)
Why fireworks glow in color.	3.20 (0.90)	How energized electrons can release energy in the form of light	2.33 (0.96)
How the battery works in a cell phone.	3.01 (0.92)	How a rechargeable galvanic element works.	2.03 (0.93)
How to separate the alcohol from a wine.	2.84 (1.05)	How to separate substance mixtures into their components	2.32 (0.96)
Why greasy dishes do not clean well with water only	2.30 (0.95)	What polar and non-polar substances are.	2.05 (0.87)
How to calculate the amount of carbon dioxide a car releases.	2.27 (0.98)	How to perform calculations on simple chemical processes.	2.04 (0.94)

Note. Sorted by descending mean values. (Four-point Likert-scale "1 = not interested" to "4 = very interested"), *n* = 621.

In order to get a deeper insight into the interest in contents with and without everyday references and to answer RQ2, a path model with MPlus 8 was also calculated. Here, chemistry-related self-concept, gender, school grade (level) and lesson type (laboratory lessons/normal chemistry lessons) were assumed to be possible predictors for the interest in chemical content with and without everyday references (Figure 1). The model has acceptable fit values (estimator ML, $\chi 2$ = 641.64, *df* = 266, $\chi 2/df$ = 2.41; *CFI* = .95, *RMSEA* = .05). Only significant values are shown in Figure 1. Results show that chemistry-related self-concept has a significant positive influence on both interest in content with (β = .31, *SE* = .04, *p* >0.00) and without everyday references (β = .45, *SE* = .04, *p* >0.00). Gender has a significant negative influence (female students have a lower interest than male students), but only on interest in content with everyday references (β = -.16, *SE* = .04, *p* >0.00). School grade (level) acts as a significant negative predictor for interest in chemical content, both for content with (β = -.24, *SE* = .04, *p* >0.00) and without everyday references (β = -.17, *SE* = .04, *p* >0.00). The lesson type (students with extra laboratory lessons have higher interest in chemical content than students who have normal chemistry lessons), on the other hand, acts as a significant positive predictor for interest in content with (β = .10, *SE* = .04, *p* = .015) and without everyday references (β = .10, *SE* = .04, *p* = .007). Through this model, 21.7 % of the variance regarding the interest in content with (R^2 = .22, *SE* = .03, *p* >0.00) and 25.1 % of the variance without everyday references (R^2 = .25, *SE* = .03, *p* >0.00) can be explained.

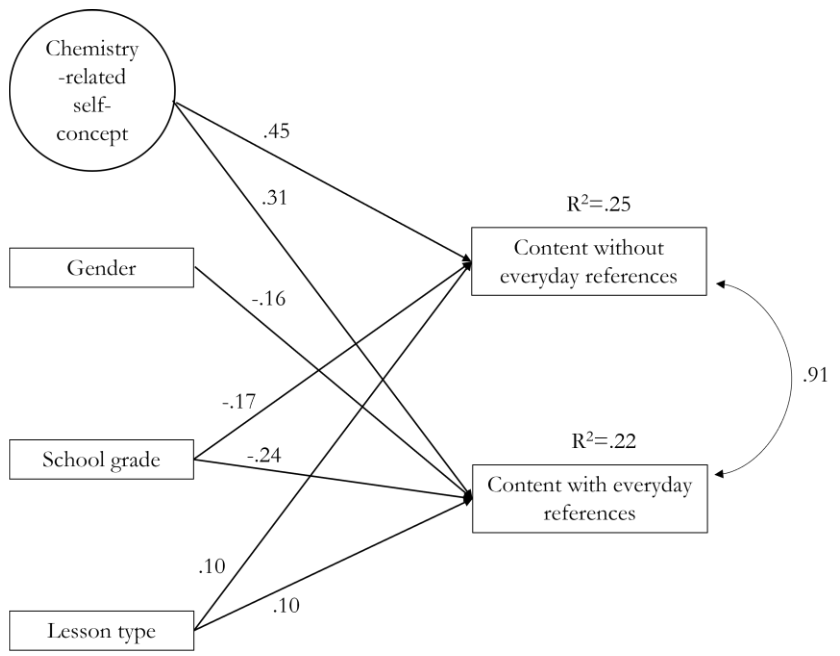

Fig. 1. Path model of school-related criteria and the interest in chemical content with and without everyday references.

Note. School-related criteria: chemistry-related self-concept, gender, school grade (level) and lesson type (laboratory lessons/normal chemistry lessons). Only significant values are shown.

4.2 Interest in experimental activities in chemistry education - Descriptives (RQ3)

Table 3 and Figure 2 show the descriptive analysis of all 9 items for the students' interest in experimental activities. The items are ordered by descending mean values. Mean values (*M*) and standard deviations (*SD*) of the items are shown (Table 3). It can be seen that conducting experiments independently (*M* = 3.56) and setting up experiments independently (*M* = 3.29) have the highest mean values, i.e., they are of most interest to the students. Specifically, for item (1), the mean value shows that the students appreciate to conduct experiments independently, as 90.3 % of the students are more interested/very interested (70.5 % very interested) in conducting experiments independently (only 4.7 % are not interested). A similar result can be seen for the own set-up of an experiment (item 2). Here, 84.4 % of the students are more interested/very interested and only 5.5 % of the students are not interested in setting up experiments independently. In contrast, the independent performing of pure measurements (item 8) attracts relatively less interest (*M* = 2.60). Here, only slightly over half of the students are more/very interested (55.6 %) and 44.4. % are rather not/not interested. This is also true for conducting experiments as a computer simulation (*M* = 2.62), which is more uninteresting for students than conducting a real experiment (item 1; *M* = 3.56). While 70.5 % of the students were very interested in the real experiments (4.7 % not interested), only 27.2 % are very interested and 19.8 % are not interested in conducting an experiment as a computer simulation. Watching the teacher conducting experiments is also of great interest (item 3; *M* = 3.22). The results show that this is more/very interesting for 83.4 % of the students (44.8 % very interested; only 6.0 % are not interested). All other experimental activities, which are not practical but cognitive (items 4-6, 9), e.g., thinking about the set-up of the experiment or how to test a hypothesis, rank between rather interesting and rather not interesting (Table 3, item 4-6). Of these cognitive activities, the students find the formulation of reaction equations the least interesting (*M* = 2.18). Only 9.3 % find this very interesting whereas 28.8 % have no interest at all and 33.5 % are rather not interested. In summary, results show that practical experimental activities (real experiment) that the students can perform independently are the most interesting for them, whereas cognitive activities associated with experimentation are comparatively uninteresting (Figure 2). This discrepancy found is not satisfactory, which is why measures are required to overcome this discrepancy (see discussion).

Tab. 3. Descriptive analysis of the interest of students in experimental activities.

Item	*M*	*SD*
(1) Conducting an experiment by yourself.	3.56	0.79
(2) Set up an experiment independently according to instructions.	3.29	0.86
(3) Observe how the teacher conducts an experiment.	3.22	0.86
(4) Thinking of the set-up for an experiment by yourself.	2.72	1.06
(5) Thinking about how to test a certain hypothesis with an experiment.	2.72	0.99
(6) Predict the results of an experiment.	2.71	0.96
(7) Conducting an experiment as a computer simulation.	2.62	1.09
(8) Carry out measurements.	2.60	0.98
(9) Formulate reaction equations for an experiment.	2.18	0.96

Note. Sorted by descending mean values. (Four-point Likert-scale "1 = not interested" to "4 = very interested"), *n* = 621.

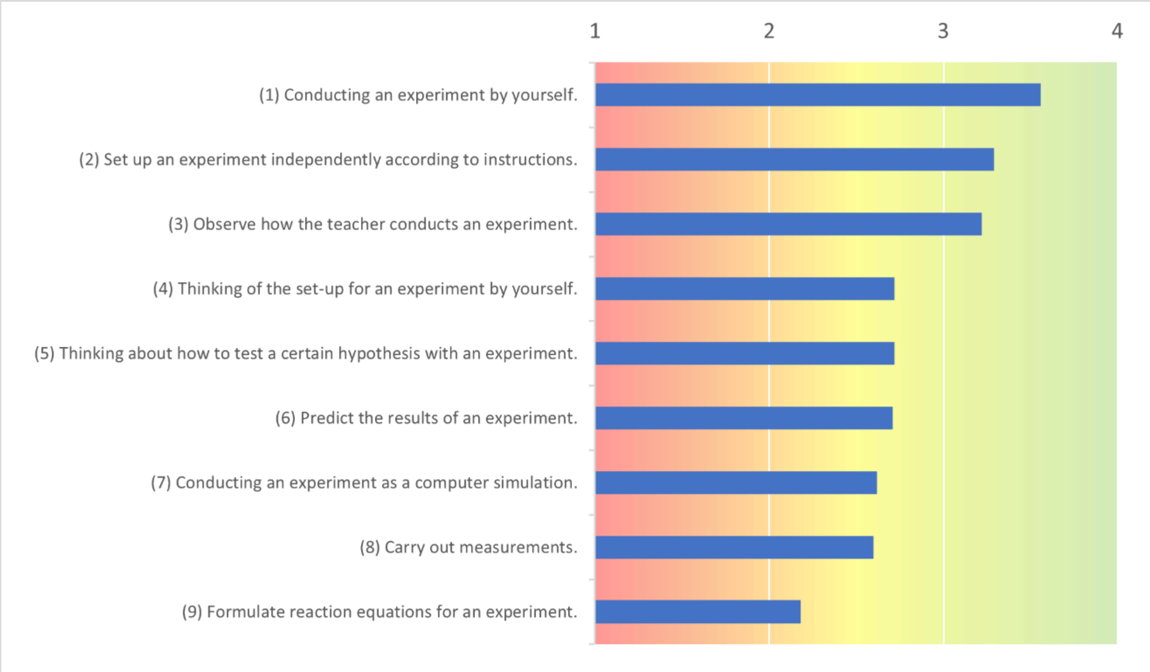

Fig. 2. Interest of students in experimental activities.

4.3 Frequency of experimental activities in chemistry education - Descriptives (RQ3)

Table 4 shows the descriptive analysis of all 10 items for the frequency of experimental activities in chemistry education. The items are ordered by descending mean values. Mean values (*M*) and standard deviations (*SD*) of the items are shown (Table 4). It can be seen that the demonstration of experiments by the teacher is the activity that occurs most frequently in the classroom (item 1 & 2, *M* = 2.68). 59.1 % of the students report that the teacher sometimes/often demonstrates experiments with special chemical equipment (laboratory equipment) (40.9 % seldom/never) and 60.4 % report that the teacher sometimes/often demonstrates experiments with everyday objects (39.6 % seldom/never). Somewhat less frequently, experiments are demonstrated using videos (*M* = 2.48) or pictures (*M* = 2.47) in chemistry education. However, the students conduct even fewer experiments independently using special chemical equipment (laboratory equipment) (item 5, *M* = 2.34) or everyday objects (item 6, *M* = 2.31). Here, both for item 5 and for item 6, there is a clear heterogeneity between the students, as 27.2 % of the students state that they never experiment independently with special chemical equipment (28.2 % with everyday objects), 29.5 % state that they seldom experiment with special chemical equipment (27,5 % with everyday objects), 25.6 % sometimes experiment with special chemical equipment (29.5 % with everyday objects), and 17.7 % often experiment with special chemical equipment (14.8 % with everyday objects). This also shows that just over half of all students in this study seldom/never experiment independently. Item 7 shows similar results, as 42.3 % of the students state that experiments are sometimes/often only discussed theoretically and not conducted. Results also show that the joint development and conduction of experiments seldom occurs in chemistry lessons (item 8 & 9, *M* = 2.20). Experiments are least often demonstrated by means of animations/apps (*M* = 1.76). Here, 49.9 % of the students state that this never occurs and only 4.8 % state that this often occurs in chemistry education. In summary, the results regarding the frequency of experimental activities are rather heterogeneous, as these activities seem to occur sometimes more often and sometimes less often in chemistry lessons. Nevertheless, it can be stated for all experimental activities (items 1-10) that these never/seldom occur in chemistry lessons for at least 40.0 % of all students. Furthermore, the trend is that teachers demonstrate experiments more often than students can experiment on their own or together with the chemistry teacher.

Tab. 4. Descriptive analysis of the frequency of experimental activities.

Item	*M*	*SD*
(1) The teacher demonstrates experiments using special chemical equipment (laboratory equipment).	2.68	1.02
(2) The teacher demonstrates experiments using everyday objects.	2.68	0.94
(3) Chemistry experiments are demonstrated in class using videos.	2.48	0.90
(4) Chemistry experiments are demonstrated in class using pictures.	2.47	0.90
(5) In class, we conduct experiments ourselves with special equipment (laboratory equipment).	2.34	1.06
(6) In class, we conduct experiments ourselves with everyday objects.	2.31	1.04
(7) Experiments are not conducted in class, but they are discussed.	2.31	0.99
(8) In class, experiments with special equipment (laboratory equipment) are developed and conducted by the teacher and us together.	2.20	1.02
(9) In class, experiments with everyday objects are developed and conducted by the teacher and us together.	2.20	1.02
(10) Chemistry experiments are demonstrated in class using animations/apps.	1.76	0.89

Note. Sorted by descending mean values. (Four-point Likert-scale “1 = never” to “4 = often”), *n* = 621.

5 Discussion

This study aimed to contribute to the research field of interest studies in chemistry education by analyzing the interest of Austrian students in chemical content with relation to everyday references and experimental activities. As interest is a transferable construct and the education systems in German-speaking countries are similar, the studies by Häussler et al. (1998), Gräber (1992a,b) and Sjøberg & Schreiner (2019), for example, are (still) valid points of reference, meaning that the results obtained are also relevant beyond Austria. The main objectives of the current study were to explore what chemical content (with or without everyday references) students are most interested in (RQ1) and what impact chemistry-related self-concept, gender, school grade and lesson type (laboratory lessons/normal chemistry lessons) have on the interest in chemical content with and without everyday references (RQ2). Further it was descriptively analyzed which experimental activities students are most interested in and how often experimental activities occur in chemistry education (RQ3). The discussion follows the research questions.

In order to investigate the students' interest in chemical content with and without a relation to everyday life (RQ1), the interest of content with everyday references was first compared descriptively with that of content without everyday references. For this purpose, items were formulated correspondingly, so that the respective chemical content was presented once with and once without reference to everyday life (see Table 2). Based on the descriptive results we found that the average level of interest in the presented contents is on a medium level (between rather not and more interested; on a four-point Likert-scale), which means that the students have a certain basic interest in the contents of chemistry education. This corresponds to the results that Schreiner (2007) found for Austrian students. It is also evident that the students are more interested in content with a relation to everyday life than in content without a relation to everyday life. Sjøberg & Schreiner (2019) also made similar findings. They describe a pattern in which interest in chemical content decreases the more it resembles the content of classic (school)books or curricula for purely subject-specific knowledge acquisition, which corresponds to our items without relevance to everyday life. Higher interest in content with relevance to everyday life was also confirmed in this study in a variance analysis, where the result shows that the interest in chemical content with everyday references is significantly greater than the interest in content without everyday references, with a strong effect. This result is in line with expectations, as several interest studies in the field of science education and chemistry education have already found similar results and emphasize the importance of everyday references for science and chemistry teaching (Apotheker, 2019; Barke et al., 2012; Broman & Simon, 2015; Elster, 2007a; Gräber, 1992a; Hayes, & O'Dwyer, 2015; Hoffmann et al., 1998; Taskinen et al., 2013).

To answer the second research question, what impact chemistry-related self-concept, gender, school grade and lesson type (laboratory lessons/normal chemistry lessons) have on the interest in chemical content with and without everyday references (RQ2), a path model was calculated. Results show that chemistry-related self-concept is a significant predictor of interest for both chemical content with (moderate) and without everyday references (strong). That is, the higher the chemistry-related self-concept, the higher the interest in chemical content, regardless of whether it is related to everyday life or not. This result is not unexpected, as other studies have found that the self-concept can have a positive influence on interest (Marsh et al., 2005; Nagy et al., 2006; Potvin & Hasni, 2014), as in this study. Conversely, Taskinen et al (2013) found that the more references to everyday life are made in science lessons, the higher the self-concept. Furthermore, gender is a significant negative but weak predictor for the interest in chemical content, but only for the content with everyday references. In this case, it means that female students have a lower interest in the everyday references presented in this study than male students. One explanation for this could be that half of the items presented are related to technology (e.g., "How the battery works in a cell phone" or "How to calculate the amount of carbon dioxide a car releases") and other studies already found that German and Austrian male students are more interested in technology-related content and female students are more interested in content related to the body or topics of their everyday life (Elster, 2007a,b; Holstermann & Bögeholz, 2007; Wanjek, 2000). Therefore, Holstermann & Bögeholz (2007) suggest taking gender-specific interest into account when teaching, so that as often as possible both male and female students feel addressed by the choice of topics (everyday references) and can develop an equal interest in the different contents. We can only agree with this. The fact that gender is not a significant predictor for content that is not related to everyday references is seen positively by the authors of this paper, as it indicates that both male and female students are equally interested in this content. Schminke et al. (2007) found a similar trend and reported an incipient change in the interest in content in chemistry education and a growing blurring of gender differences in interest in chemical content. Further, school grade (level) is a significant negative (weak) predictor for the interest in chemical contents for both with and without everyday references. This means that the higher the school grade (level), the less interest students have in chemical content, regardless of whether it is related to everyday life or not. Several studies confirm this result and show that interest in science and chemistry seems to decline during the school career (Gräber, 1992a; Hoffmann et al., 1998; Köller et al., 2020; Sjøberg & Schreiner, 2019). One possible explanation for the decline in interest in science is the differentiation of interests in the course of puberty. However, interest in the natural sciences, particularly in chemistry and physics, declines much more compared to other subjects (Krapp & Prenzel, 2011; Ochsen et al., 2022). Finally, the lesson type is a significant but weak predictor for the interest in chemical content, both for the interest in content with everyday and without everyday references. In this case, it means that students who attend extra laboratory lessons have a higher interest in chemical content than students who have normal chemistry lessons. This may be because students have the opportunity to conduct more experiments in the laboratory lessons than in normal chemistry lessons and thus can also work on the chemistry content in a more practical way. However, further research is needed to confirm this assumption.

To investigate the students' interest in experimental activities and the frequency of experimental activities in chemistry education (RQ3), both were analyzed descriptively (Table 3 & 4, Figure 2). Based on the descriptive results we found that students are most interested in conducting experiments independently, setting up experiments independently and watching the teacher conducting experiments. Gräber (1992b) and Woest (1997) already found similar results for chemistry education as well as Herbst et al. (2016) for physics education and Shirazi (2017) for science education, and Schminke et al. (2007) also found a significantly higher interest for the test group in a control group comparison, in which the test group received practice-oriented lessons with reference to everyday life and experiments to be conducted independently, and the control group did not receive practice-oriented lessons. Thus, we were able to confirm these most popular experimental activities again after more than 20 years (in comparison to Gräber (1992b) and Woest (1997)). At the same time, however, we found in our study that although experiments are frequently demonstrated by the teacher, independent experimentation, which is the most interesting activity for the students, is much less common in chemistry lessons, as Schreiner (2007) already found for Austrian students in science education. Schminke et al. (2007) note that it is particularly up to the teacher which elements and activities, e.g., everyday references and independent experimentation by the students, occur in chemistry lessons. In this context, Shirazi (2017) found that the teacher in particular can have a positive but also a negative influence on the experience of school science. Hattie (2009, 2012) has also already described the crucial role of the teacher in designing lessons and their impact on student achievement. Schminke et al. (2007) also points out that too little research has been done on the role of teachers in relation to students' interests in chemistry education. Therefore, more attention should be paid to this topic in the future. Emden et al. (2019) also point out that experiments are undoubtedly part of modern science teaching. According to these authors, however, students often only know experimentation as a tool whose usefulness cannot be properly assessed and is therefore understood more as a compulsory element of teaching that must be done. This implicitly promotes a passive consumer attitude on the part of the learners. However, experimentation in school can have a much greater potential. It can encourage learners to actively engage with unknown topics/content as well as their environment (everyday references) and thus also fulfils an educational function. Therefore, an attempt should be made to provide answers to the question of why all students should learn to experiment, not by watching, but by actively experimenting themselves, which enables formal education (Emden et al., 2019) and once again, we have found that conducting experiments independently is the most interesting activity for the students. Students find cognitive activities associated with the experiment, such as formulating reaction equations, the least interesting. Schminke et al. (2007) speaks of theoretical-constructive activities, Woest (1997) of abstract theoretical activities. Both authors (teams) also found that these activities met with little interest among students. Gräber (1992a) notes that it is exactly these more abstract activities that students find difficult and that interest in the subject declines as a result. Shirazi (2017) found similar findings for science education in her study. However, the fact that the interest in experimental activities has hardly changed in the last 20 years and that the haptic experimentation skills are more interesting than the cognitive experimentation skills is not a satisfactory development for chemistry education. From the authors' point of view, both haptic and cognitive experimental activities/skills should be understood as a unit, which should also be taught to students in chemistry lessons. One approach could be the integration of inquiry-based learning, which is a widely accepted teaching and learning approach for science education. Inquiry-based learning places the self-directed experimentation of students at the center, whereby the experiment as a central method of scientific knowledge plays an important role (Baur et al., 2020; Eckhardt et al., 2013), includes both the cognitive and haptic (manual) skills discussed above (Maiseyenka et al., 2013) and is also in the spirit of Emden et al. (2019). According to Nawrath et al. (2011), individual or several experimental sub-skills can be specifically addressed in lessons so that students are not overwhelmed during inquiry-based learning. Inquiry-based learning should therefore be practiced continuously in chemistry education. In this way, cognitive activities that are rather uninteresting and perceived as difficult by the students, such as formulating and testing hypotheses, (measuring) and formulating reaction equations, could be meaningfully linked to the students' independent experimentation, which as described above, is of the greatest interest to the students. The study by Fleischer et al. (2024), which focused on the activities of formulating hypotheses, measuring, and testing hypotheses, which are rather uninteresting for students, provides a promising result in this regard. The students independently conducted an everyday oriented experiment on the cooling effect of alternative ice cubes made of granite, soapstone, and ceramic, measuring their cooling effect compared to a normal water ice cube with the help of a digital temperature sensor. Overall, this study has shown, for the majority of students, that everyday oriented experiments in the spirit of inquiry-based learning represent a promising approach to support the experimental sub-skills of formulating hypothesis, measuring, and testing hypothesis, and could thus arouse interest in these rather uninteresting activities during experimentation.

Limitations

Some limitations of this study need to be acknowledged. First, these results are limited by the fact that the survey was conducted at one point in time, in this case approximately in the middle of a school year. Unfortunately, due to practical limitations, such as contacting the schools, time for forwarding the questionnaire to the students and period for completing the questionnaire, it was not possible to conduct the study later in the current school year, e.g., at the end of a school year. Nevertheless, all students had sufficient chemistry lessons to gather impressions from their previous chemistry lessons, especially in terms of interest and frequency in experimental activities. To obtain further insight, it would be valuable to repeat such an interest study in the next years, to be able to represent as far as possible a current level of interest regarding chemistry education in Austria. In this way, possible changes in interest compared to previous older interest studies could be determined. Further, in interest studies, as in this study, students are asked how interested they are in certain content. According to Gräber (1992b), however, this can lead to the problem that the students have different associations with such items, especially in the case of general formulations such as "how to separate substance mixtures into their components". For example, some students might think of the construction of a distillation apparatus, others of scientific content such as boiling point or technical terms such as evaporation and condensation. Depending on the association, this chemical content could be more or less interesting for the students. In order to get more clarity here, follow-up studies could, for example, specifically ask about the students' associations and then relate these to the interest in the respective content. Nevertheless, the items of a questionnaire must be formulated concisely, so that the items can be answered by the students in a reasonable amount of time. Finally, the results of this study are limited to the self-reporting of the students. However, the results discussed are in line with the results of various interest studies that had a similar research design. For further research it would certainly be interesting to focus on the teachers as well and to investigate the question why teachers think chemistry education is interesting or uninteresting for their students and how students' interest in chemistry education could be increased from the teachers' perspective.

6 Conclusions

The study provides new and current insights into the interest of Austrian students in chemical content with and without everyday references in chemistry education. Furthermore, the study shows which experimental activities students are most interested in and how often experimental activities occur in chemistry lessons. We took a detailed look at interest in chemical content and analyzed corresponding items with and without reference to everyday life. The findings show that learners are significantly more interested in content with everyday references than in content without everyday references. Furthermore, this study showed that independent experimentation is of greatest interest for students, but at the same time occurs relatively rarely in chemistry lessons. Less popular, on the other hand, are abstract activities such as formulating reaction equations in the context of experiments. Results also reveal that chemistry-related self-concept is a moderate/strong predictor for the interest in chemical content for both with and without everyday references. The other predictors (gender, school grade, lesson type) each only have a weak influence on interest in this content. However, the results have shown that interest in chemistry content declines over the school career, just as other studies have previously found a declining interest in chemistry/science education (Gräber, 1992a, Köller et al., 2020; Sjøberg & Schreiner, 2019). Therefore, it seems to be a difficult task to counteract this drop of interest, which has not yet been solved. One way of counteracting this loss of interest could be to teach with as much of the focus on everyday life as possible, considering the interests of female and male students when choosing the everyday reference and enabling the students to experiment independently, preferably with reference to everyday life, as often as possible. After all, this is what summarizes the greatest interests of students in chemistry education in this study. This appears to be possible by integrating inquiry-based learning in an everyday oriented manner, as the focus here is on independent experimentation by the students and both cognitive and haptic experimental activities/skills are understood as a unit. As inquiry-based learning is quite complex for students, it must be practiced regularly in chemistry lessons. However, further research will be required on how to counteract this loss of interest. Overall, our findings contribute to the research field of interest studies in science education, especially for chemistry education, and offer a current insight into the interest of Austrian students in chemical content as well as in experimental activities in chemistry education.

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